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A/PROV

PROVISIONAL APPLICATION FOR PATENT COVER SHEET (Small Entity)

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53 (c).

JC541 U.S. PTO 60/122687 03/03/99

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☐ *Additional inventors are being named on page 2 attached hereto*

TITLE OF THE INVENTION (280 characters max)

COMPUTER COMMUNICATION

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ENCLOSED APPLICATION PARTS *(check all that apply)*

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inc. appendices A1-10, B1-9, C1-5

☒ Drawing(s) *Number of Sheets* 7

☒ Small Entity Statement

☒ Other (specify) Assignment + recordation

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT *(check one)*

☐ A check or money order is enclosed to cover the filing fees

☒ The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 03-3419

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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

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Respectfully submitted,

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Date 03/03/1999

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USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

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P15SMALL/REV04

PROVISIONAL APPLICATION FOR PATENT COVER SHEET (Small Entity)

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P19SMALL/REV04

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) AND 1.27 (c)) - SMALL BUSINESS CONCERN			Docket No. 100/00809
Serial No.	Filing Date HEREWITH	Patent No.	Issue Date

Applicant/
Patentee: Alon ATSMON

Invention:
COMPUTER COMMUNICATION

I hereby declare that I am:

☐ the owner of the small business concern identified below:
☒ an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF CONCERN: COMSENSE TECHNOLOGIES, LTD.
ADDRESS OF CONCERN: 35 JABOTINSKY STREET, TWIN TOWERS 2, RAMAT-GAN 52511

I hereby declare that the above identified small business concern qualifies as a small business concern as defined in 13 CFR 121.3-18, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

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☒ the specification filed herewith with title as listed above.
☐ the application identified above.
☐ the patent identified above.

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- ☒ no such person, concern or organization exists.
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Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27)

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF PERSON SIGNING: Alon ATSMON
TITLE OF PERSON SIGNING OTHER THAN OWNER: GENERAL MANAGER
ADDRESS OF PERSON SIGNING: 131/2 BEN-GURION STREET, YEHUD 56209, ISRAEL.

SIGNATURE: DATE: 3/3/99

03/03 '99 WED 21:08 FAX 972 3 9215383 FENSTER & CO 008

COMPUTER COMMUNICATION

FIELD OF INVENTION

The present invention relates generally to electronic devices that communicate among themselves using acoustic transmissions, especially using communication channels designed for communicating with humans.

BACKGROUND OF THE INVENTION

Computer network components that communicate using RF radiation, wires or IR radiation are well known. In addition, some home appliances are controlled using an ultrasonic remote control. Also known are smart cards that use an ultrasonic acoustic link.

However, such dedicated communication mechanisms require that the computer network components have installed thereon specialized communication hardware. Installing such hardware on an existing computer may be expensive and/or problematic. Further, some electronic and/or computer embedded devices, for example cellular telephones may be "sealed" products, to which it is impossible to add internal components.

PCT publications WO96/10880, WO94/17498, WO93/21720 and WO93/11619, the disclosures of which are incorporated herein by reference describe an electronic device which transmits coded information to a microphone of a telephone using a DTMF-like encoding scheme. A WWW page addressed "http://www.encotone.com/html/tech_def.html", suggests using such a device to transmit audible DTMF-like tones to a personal computer using the computer's sound card.

Two way communication using audible DTMF-like tones, between a smart card and a telephone communication system is described in US patent 5,583,933, the disclosure of which is incorporated herein by reference.

SUMMARY OF THE INVENTION

One object of some preferred embodiments of the invention is to simplify interaction between electronic devices by removing a common requirement of installing dedicated communication hardware on the devices. Some suitable electronic devices include: computers, televisions, watches, PDAs, organizers, electronic toys, electronic games, voice-responsive appliances, wireless communication devices, answering machines and desktop telephones. As used herein the term "electronic device" is used to encompass a broad range of electronics-including devices. In some of the embodiments described below, a particular type of electronic device is singled out, for example a computer or a toy, as some of the below-described embodiments are more useful for some types of electronic devices, than for other types of electronic devices.

An object of some preferred embodiments of the invention is allowing electronic devices to communicate using an input and/or output channel, preferably an acoustic channel, but possibly a visual channel, which was designed for communication with human users and not for communication with electronic devices. In other cases, the communication channel is not originally intended for communication with outside components at all, for example, a diskette drive.

An object of some preferred embodiments of the invention is to allow a smart card to be read by and written to using standard computer hardware without requiring an installation of specialized hardware. This is especially useful for electronic wallets and Internet commerce, where the cost of installing dedicated hardware may prevent wide acceptance of these commercial methods. Additionally, using a smart card can provide methods of solving the security and accountability issues entailed in electronic commerce.

An aspect of some preferred embodiments of the invention relates to communicating with a computer using a sound card installed on the computer. In a preferred embodiment of the invention, a device, preferably a smart card, transmits information to the sound card's microphone and receives information form the computer using the sound card's loudspeaker. Preferably, the transmission uses non-audible acoustic frequencies, for example ultrasonic or infrasonic frequencies. It should be noted that standard music cards are designed for music generation, however, they have a limited reception and transmission ability in the near-ultrasonic frequency ranges.

Ultrasonic communication has several advantages over audio communication:

(a) smaller transducers can be used;

(b) transmission is more efficient;

(c) lower noise levels are typical;

(d) resonant frequencies have wavelengths on the order of a size of a credit card can be used; and

(e) higher data rates can be achieved.

In a preferred embodiment of the invention, the ultrasonic frequencies used are low ultrasonic frequencies, for example between 18 kHz and 24 kHz, more preferably between 20 kHz and 24kHz, and in some preferred embodiments about 22kHz. Often, these frequencies can be transmitted and/or received using standard audio components. For this reason, lower frequencies may be preferred over higher frequencies, even though the lower frequencies typically afford a lower data rate and are more easily disrupted. These particular frequencies are suggested because they match industry standards for sampling in audio cards (e.g., "SoundBlaster"). If other sampling frequencies are available, the preferred frequency may

adjusted accordingly. Preferably, a minimum frequency used is selected so that it is inaudible to a human. In some cases, the frequency selection may depend on the age of the human.

A benefit of ultrasound over RF transmission is that the range of the ultrasonic transmission can easily be controlled by varying its amplitude. Typically, ultrasonic transmissions do not pass through walls, potentially providing increased security by limiting eavesdropping and inference from outside the room. In addition, ultrasonic transmission usually do not interfere with the operation of electronic equipment, even when used at a high power setting. Thus, ultrasonic communication is better suited for people with pacemakers and for hospital settings. Another advantage of acoustic transmission is a reduced perceived and actual health danger to the user.

An aspect of some preferred embodiments of the invention relates to communication between electronic devices using acoustics. Alternatively or additionally to electronic devices communicating using RF; varying magnetic fields; IR; and visible light, electronic devices may communicate using acoustics, in accordance with preferred embodiments of the invention. In some cases, one communication direction is acoustic and the other is non-acoustic, for example RF or IR, for example when communicating with a set-top box in accordance with a preferred embodiment of the invention (one way acoustic from the TV and the other way IR, the same as an IR remote control). In a preferred embodiment of the invention, the acoustic waves used for communications are incorporated in sounds used for regular operation of the device, for example by modulating beeps. Alternatively or additionally, the sounds are inaudible, for example being ultrasonic, infrasonic, of a low amplitude and/or causing only small changes in amplitude and/or frequency.

It is noted that many electronic devices include a microphone and/or a speaker. In a preferred embodiment of the invention, the microphone and/or speaker are used to communicate with the device. In one example, an acoustic smart card (or an "electronic wallet" card) communicates with such a device using sound and/or ultrasound. Such a smart card may transmit information stored thereon. Possibly, the information is encrypted, for example, using RSA encryption.

In a preferred embodiment of the invention, a smart card may be "swiped" at practically any existing computer and many existing electronic devices, possibly requiring a simple software installation, but no hardware installation (assuming some acoustic hardware exists). Such simple swiping should ease acceptance of the card by Internet browsing home shoppers. In some cases, the swiping software may be downloaded as a Java Applet.

Alternatively or additionally, two electronic devices can communicate. For example a cellular telephone and a PDA, each of which includes a microphone and a speaker can

communicate. Another example is programming a cellular telephone with names and numbers stored in a PDA or for the cellular phone to interrogate the PDA regarding a particular telephone number. Alternatively or additionally, a network may be formed of a plurality of such devices, possibly, with one device forwarding messages from a first device to a second device. Alternatively or additionally, peripherals may be connected to a computer using an acoustic connection, without requiring wiring or special hardware. In some embodiments, a single acoustic transducer (microphone or speaker) may be controllable to act as both a receiver and a transmitter, by suitably programming the electronic device.

Many computers are sold with a Sound-Blaster Compatible sound subsystem, stereo speakers and a microphone. Some computers are provided with other types of sound systems, which types also support the application of preferred embodiments of the invention, possibly with a variation in frequencies to account for different circuit or sampling characteristics. Typically, this sound system is designed for generating music and other audible sounds. In addition, many computers include an internal speaker and a modem speaker. Some computers use USB speakers which are connected directly to the USB.

It should be appreciated that in some embodiments of the invention the sound communication is directed at the device for its use, control and/or processing and is not meant for mere passing through the device. For example, a telephone may interpret computer-information encoding signals, rather than transmitting them on through the telephone network, as in the art. In a preferred embodiment of the invention, a wireless telephone is realized using ultrasonic communication between a base station and the hand set. In a preferred embodiment of the invention, the base station is embodied in a computer, which communicates with the telephone. Possibly, the wireless communication uses the same loudspeaker and/or microphone as used for communication with a person using the telephone and the computer. Additionally or alternatively, the handset is used for Internet telephony, via the computer.

An aspect of some preferred embodiments of the invention relates to interfacing a toy and/or other devices with a computer system without installing hardware on the computer. In one example, the loudspeakers, already installed on a computer, are used to interrogate an identification device, using ultrasound. In another example, such interrogation is used to determine distance from- and/or location of- a toy. Preferably, the computer's microphone is used to detect a response from the interrogated device. In some embodiments, especially for toys, the interrogation may comprise audible sounds. Thus, in a preferred embodiment of the invention, cheap and/or simple communication between a toy and another toy or a computer is feasible, since no special computer hardware is required. In addition, it becomes simpler to connect a play implement to a computer game that responds to that play implement.

Additionally or alternatively, ultrasonic communications may be used to download a program and or music file to a toy. Possibly, the program and/or music file are directly downloaded from an Internet as sound files, possibly obviating the need for a dedicated toy (or device) programming software interface. Possibly, the toy and/or device generate sounds in response which sounds are transmitted back through the Internet.

In a preferred embodiment of the invention, the acoustic waves used for communication or possibly, dedicated acoustic waves, may be used to determine the relative position and/or orientation of electronic devices. In a preferred embodiment of the invention, a touch screen is emulated by interrogating a transponder on a pointing implement, using built-in speakers of an electronic device, to detect to position, orientation and/or motion of the implement. In a preferred embodiment of the invention, the transponder is embodied using a speaker and a microphone of the pointing implement, for example if the implement is a cellular telephone.

For example, one or more of the following sound generators may be available in a personal computer: built-in speaker, modem speaker and sounds generated by mechanical devices, such as a hard disk drive or a diskette drive. These sound generators may also be used for transmitting information.

An aspect of some preferred embodiments of the invention relates to inactivating a stolen electronic device. In a preferred embodiment of the invention, the electronic device interrogates an acoustic transponder using the device's built-in speaker and/or microphone. If the transponder does not respond (e.g., the device was stolen and separated from the transponder), the device does not work. If possible, the device transmits a message to an enforcement authority or to the owner, for example by computer network (e.g., for a laptop computer) or by wireless communication (e.g., for a cellular telephone). A particular type of stolen property is copyrighted software, which can be programmed to interrogate a transponder which is nearby, e.g., attached to a case of the software and/or the computer. An illegal copy of the software will have no available transponder to respond to an interrogation, thereby identifying itself as stolen. Optionally, the program them communicates with the copyright owner.

An aspect of some preferred embodiments of the invention relates to authorization and authentication over an Internet or another type of communication network, using sound. Preferably, the normal communication pathway is not changed, except that the two ends of the pathway may require hardware or software for manipulating sound signals. In one example, a smart-card transmits an encoded acoustic signal to a computer. That signal is transmitted over the Internet to a remote server computer, to serve as authorization for debiting an account. In

another example, in which information is transmitted in the opposite direction, a coded signal may be provided from a toy program depository, to be downloaded using acoustic waves to a toy that is near the computer. Such a coded signal may also be used to download information to a smart card.

An aspect of some preferred embodiments of the invention relates to transmission of power to a smart card. Preferably, the received power is stored to be used for transmission and/or processing. In a preferred embodiment of the invention, the power is stored for short periods of time, for example several seconds. Alternatively, at least some of the power is stored for longer periods of time, for example minutes or hours. In a preferred embodiment of the invention, the power is transmitted using an acoustic wave, preferably an ultrasonic wave, possibly the same wave as used for communication. Generally however, the power wave is transmitted for a considerably longer duration than an information wave. Additionally or alternatively, power is transmitted using optical energy which is received by photoelectric cells on the smart card. In one example, a smart card is placed near a display to receive energy from the display. Possibly, the energy is modulated, spatially or temporally, to transmit information to the smart card, in addition to transmitting power. Alternatively or additionally, the card may receive (and store) power radiated by the screen control circuitry as electromagnetic signals.

An aspect of some preferred embodiments of the invention relates to smart card construction. In a preferred embodiment of the invention, the entire card is formed of a piezoelectric material and the frequencies transmitted and/or received by the smart card are a function of the acoustic characteristics of the card. Additionally or alternatively, only a portion of the card is electrified for transmission and/or reception, for example, only a magnetic strip of an image pasted thereon. Additionally or alternatively, only a portion of the card is polarized during manufacture, to possess a required piezoelectric effect.

An aspect of some preferred embodiments of the invention relates to using a computer microphone to acquire ambient sounds, then analyzing these sounds using a computer, and then using the analysis to determine events occurring in its neighborhood. In a preferred embodiment of the invention, electronic devices are designed and/or programmed to generate sounds (possibly in the ultrasonic range), which sounds represent their current state or particular events. Thus, by eavesdropping on these sounds it is possible to determine the status of electronic devices. In one example, a malfunctioning fax machine will generate one hum and/or an arriving fax on an operating fax machine will generate a different hum or sound pattern. A computer near the fax machine can determine the status and events and transmit this information, possibly using a computer network, to a user of the information. In some cases, the existing sounds generated by a fax (beeping, printing noises etc.) can be identified by the

computer, without need for special programming of the fax machine to generate novel sounds.

An aspect of some preferred embodiments of the invention relates to interrogating an electronic device using an acoustic channel. Such interrogation should not adversely affect the operation of the devices. In one example, the device is a network component, such as a hub. In another example, the device is a computer. In a preferred embodiment of the invention, the acoustic channel is controlled by the computer (analysis of incoming information, generation of outgoing transmissions, and possibly execution of certain software) without interfering with the work of a person using that computer, for example word processing work.

An aspect of some preferred embodiments of the invention relates to using a smart card to conduct business transactions, especially at restaurants. In a preferred embodiment of the invention, an acoustic smart card is used to perform one or more of receiving a menu, ordering, getting the attention of a waiter, adding up a bill, allowing a user to add a tip and settling a bill. Such a smart card may communication directly with a central computer at the restaurant. Alternatively, the smart card communicates using strategically placed loudspeakers and microphones in the restaurant, for example placed at each table. Possibly the smart card communicates with a computer or a PDA used by the waiter. In a preferred embodiment of the invention, the smart card negotiates bandwidth requirements with other smart cards in the restaurant, so that they do not interfere with each other.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more clearly understood with reference to the following detailed descriptions of non-limiting preferred embodiments of the invention in which:

Fig. 1 is a schematic illustration of a computer and an electronic device which are operative to communicate using sound waves, in accordance with a preferred embodiment of the invention;

Fig. 2 is a schematic illustration of two communicating electronic devices, in accordance with a preferred embodiment of the invention;

Fig. 3A is a schematic illustration of a smart card communicating with a computer, in accordance with a preferred embodiment of the invention;

Figs. 3B-3D are schematic illustrations of smart card construction in accordance with preferred embodiments of the invention;

Fig. 3E is a schematic illustration of a smart-card reader in accordance with a preferred embodiment of the invention;

Fig. 4A is a schematic illustration of an Internet transmission pathway for sounds, in accordance with a preferred embodiment of the invention;

Fig. 4B is a schematic illustration of usage of a smart card in a restaurant setting, in accordance with a preferred embodiment of the invention;

Fig. 5 is a schematic illustration of a method of tapping into a computer, without requiring complicated installation of hardware, in accordance with a preferred embodiment of the invention;

Fig. 6 is a schematic illustration of an unobtrusive computer checkup in accordance with a preferred embodiment of the invention;

Fig. 7 is a schematic illustration of a computer communication setup using acoustics, in accordance with a preferred embodiment of the invention; and

Figs. 8A and 8B comprise an electronic schematic of an ultrasonic circuit in accordance with a preferred embodiment of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Fig. 1 is a schematic illustration of a computer 20 and an electronic device 30, which are operative to communicate using sound waves, in accordance with a preferred embodiment of the invention. Most computers currently on sale include a sound system 24, usually a sound card, connected to at least one microphone 26 and at least one speaker 28. Many electronic devices include a microphone 34 and a speaker 36. In a preferred embodiment of the invention, computer 20 and electronic device 30 communicate using these standard components, which are usually not designed for computer communication but for human communication. In some cases, the electronic device (or the computer) may include a jack to which one or more speakers and one or more microphones may be connected. Preferably, such connected acoustic elements are positioned on a hard to obstruct portion of the device, preferably at positions where they have a wide field of view.

In one preferred embodiment of the invention, a standard card, such as the popular "Sound-Blaster" is used to generate sonic and/or ultrasonic signals to (and receive from) an electronic device, a toy and/or another object. The acoustic signal may be audible or inaudible, for example being ultrasonic or infrasonic. Preferably, frequencies of about 20kHz, 22kHz and 24kHz are used, since a standard sound card provides these sampling rates (and/or their multiples, e.g., 48kHz).

In some preferred embodiments of the invention, a sound card is adapted to work in the near ultrasonic range, for example by increasing its sampling frequency. Generally, the microphone and loudspeaker used for a computer system can support low frequency ultrasound with a sufficient fidelity. In some cases however, a special ultrasound-sensitive microphone or ultrasound-effective speaker may be used. In other cases, the sensitivity of a particular microphone and/or loudspeaker maybe determined by the user prior to or during

communication with an electronic device. In one example, if a device having known characteristics transmits an equally powerful signal at several frequencies, the frequency sensitivity (and/or directional sensitively) of a microphone may be determined. In a similar manner, a computer may generate these sounds and the signals detected by the device analyzed to determine output characteristics of the particular loudspeaker used. In addition, a self-calibration procedure may be performed by listening to the computer's output using the computer's microphone. In some cases, both the device and the computer sound systems can be calibrated by combining self testing and cross-testing.

In some cases, the microphone and/or the sound card are sensitive enough to receive, from the object, an RF signal associated with generating the acoustic signals, even if an acoustic signal is not sent (e.g., no loudspeaker is present).

In a preferred embodiment of the invention, such an acoustic communication may be used to program a toy and/or retrieve information from a toy, for example replacing an RF link for this purpose as described in US patent number 5,752,880, the disclosure of which is incorporated herein by reference. In a particular embodiment, music may be downloaded from the Internet, directly to the toy, for example by modulating an ultrasonic signal to carry MP3 sound files. Alternatively or additionally, such a link may be used for real-time communication with the toy.

Some embodiments of the invention do not require that the electronic device communicate with a computer. Fig. 2 is a schematic illustration of two communicating electronic devices 30 and 30'. In one example, a PDA communicates with a printer. In another, an organizer communicates with a satellite telephone. Possibly, such communication is used to exchange data files and/or to share capabilities, such as modem connections. In some cases a port adapter may be required to be plugged into a port, for example a sonic-to-parallel adapter, which converts between acoustic signals and parallel port signals.

A computer network in accordance with a preferred embodiment of the invention utilizes sound waves transmitted between computers for communication, using existing hardware, such as an audio card, loudspeakers and a microphone. Preferably, the sound waves are ultrasound waves. In a preferred embodiment of the invention, such a computer network is used to connect a PDA or a portable computer to a different computer, for example for data transfer or for sharing peripherals, such as a modem, a printer or a storage device. Thus, an existing PDA (which includes a loudspeaker and a microphone) can use a modem of a desk-top computer, without requiring additional hardware in the PDA, possibly requiring only a small software change. In another example an acoustic-enabled smart-card (such as that described below), can print, or backup information using a standard desktop computer.

Alternatively or additionally, such a network may be used in a small office, for example for file or printer sharing.

In a preferred embodiment of the invention, a standard communication protocol/language is defined, so that many types of devices can communicate and/or share resources using the standard language.

In a preferred embodiment of the invention, sonic and/or ultrasonic communication is used for paying a toll or a fee (human, package or vehicle), utilizing a reactive component, possibly a passive transponder, on the tolled item. In another example, such communication is used to pay a transportation fee, for example on a subway or a bus. Alternatively or additionally, an acoustic mechanism as described herein is used to open vehicle barriers, for example at entrances to apartment complexes or to open garage doors. Alternatively or additionally, the acoustic mechanism is used for automatic refueling/billing systems, possibly transmitting billing and/or mileage information to a pump receiver, controlling the fuel flow and/or verifying the fuel type. Possibly, a car dashboard speaker, a car horn, an alarm speaker, a car radio speaker or a dedicated speaker, is used to sound the required sonic and/or ultrasonic signals. In a preferred embodiment of the invention, a car radio speaker is made to generate the required sounds by transmitting an electromagnetic wave to the radio or to its loudspeaker, from a specialized electronic device.

Alternatively or additionally, to using a computer, in a preferred embodiment of the invention, a set-top box is used to transmit and/or receive acoustic signals. Preferably, a microphone is connected to the set-top box. Alternatively or additionally, the transmission back to the set-top box uses an IR signal, which is detectable by the set-top box. In one example, the set-top box includes software that analyzes signals. Such signals may comprise responses of electronic devices and/or toys to sounds generated by the television or by the set-top box. Alternatively or additionally, the set-top box adds sounds (or ultrasonic waves) to a video and/or audio stream decompressed by the set-top box. Alternatively or additionally, the set-top box adds temporal and/or spatial optical modulations to a video stream, for an optically-sensitive electronic device to detect.

In a preferred embodiment of the invention, the detection of a signal by an electronic device (or a computer) comprises a binary detection of the signal, e.g., an on/off state. Additionally or alternatively, more complex signal detection and analysis techniques may be implemented, for example, detection of signal amplitude, frequency, frequency spectrum, Doppler shift, change in amplitude and/or duration, detection of a number of repetitions, voice and/or other pattern recognition in the sound. Various information encoding protocols may be used, including AM, FM, PSK, QPSK and pulse length encoding. The transmitted signal may

include one or more of information about the sending device's activities, location, environment, nearby devices, locally sensed information, logic state, readiness, requests for information and/or answers to such requests.

Such signal detection and/or analysis may also be performed on a computer that is in communication with the electronic device. The physical detection circuit is preferably located on the toy. Additionally or alternatively, the detection circuit is also located on the computer.

In a preferred embodiment of the invention, microphone 34 (or microphone 26) comprises a directional microphone, for example a stereophonic microphone or a microphone in which the frequency response is spatially non-uniform.

PCT application PCT/IL98/00450, titled "The Control of Toys and Devices by Sounds", filed September 16, 1998, in the Israeli receiving office, the disclosure of which is incorporated herein by reference, describes sound actuated toys. In particular, the application describes various sound makers that generate sounds inadvertently as a result of motion, for example beads in a box or noise form a crinkle material. Such a sound maker is connected to and/or mounted on a toy, so that when the toy moves a signal will be generated for another toy or device to acquire. This PCT application also describes detecting the direction and/or position of a sound, using directional microphones and/or a stereophonic microphone including two or more microphone elements. Additionally or alternatively, a relative distance is determined based on amplitude of the sound.

Israel application 127,569, filed December 14, 1998, titled "Interactive Toys", the disclosure of which is incorporated herein by reference, describes various toys and electronic devices which interact using sound waves. These applications contain information useful in the design and use of acoustically controlled devices, and which may be applied towards some preferred embodiments of the invention.

Fig. 3A is a schematic illustration of a smart card 40 that communicates with a computer. Although a smart card is a special case of an electronic device, it is noted that typical smart cards do not include an acoustic input/output channel, especially not an ultrasonic one.

In a preferred embodiment of the invention, smart card 40 comprises an acoustic element 42, a processor 44 that controls the acoustic element and a memory 46 for storing information. Such a smart card may use a single piezoelectric transducer (possibly a film layer) for both transmission and reception.

In a preferred embodiment of the invention, the received signals from element 42 are amplified to TTL levels and connected directly into one or more data lines of the micro-controller. This "data" may be treated as binary sampled input and analyzed to determine

characteristics of the received signals, for example using Fourier analysis. Thus, a high acoustic frequency can be detected and/or analyzed, without requiring a separate A/D. Preferably, the signal is amplified by various amounts, such as by several multiples of two and amplified amount is connected in parallel to a different one of the data legs, so that multi-level signal detection is facilitated. Alternatively or additionally, one or more data lines may be directly (i.e., no D/A, put possibly an amplifier or an isolator) coupled to a loudspeaker, to generate an output acoustic signal.

As many electronic devices include a speaker and/or a microphone, such a card may communicate with any such device that has suitable software. Due to the decreasing size of electronics, in some cases, a smart card may be emulated using a PDA (or vice-versa), with regard to both size and functionality. Additionally or alternatively, such smart card functionality may be exhibited by a cellular telephone or a lap top computer. A benefit of a lap top computer and of a PDA is their convenient user-interface. A benefit of a cellular telephone is the possibility of real-time and/or off-line communication with a central location.

In a preferred embodiment of the invention, the smart-card includes a battery, for example a lithium ion battery for providing power to transmit, receive and/or process acoustic signals. Possibly, the battery is rechargeable. Additionally or alternatively, the smart-card is light-powered. Additionally or alternatively, the smart-card includes a battery which is charged by optical wavelength energy, for example using a photoelectric cell on the smart-card. In a preferred embodiment of the invention, the card is recharged by placing it against a computer screen or a TV screen that is lit up. Preferably, the illumination of the screen is modified, spatially and/or temporally, to transmit information to the card. The modification of the illumination may be by a computer or by a set-top box. Transmission back to the computer and/or set-top box may be achieved using other methods described in this application.

Additionally or alternatively, power to activate the smart card and/or to recharge its power cell may be provided from via speaker. Preferably, the power is provided as an ultrasonic wave, possibly, but not necessarily, the same wave used to transmit information to the card. In this and other embodiments of a smart card, a single circuit is optionally used to receive both power and transmissions. Possibly, at least part of the same circuit is also used to transmit signals. Although the power levels are generally low, the duration of transmission of power can be made relatively longer (minutes, hours) than the duration of the power usage (micro seconds, milliseconds).

Additionally or alternatively, the card may be recharged by plugging it into a PC-card slot, a USB plug or a different suitably-sized communication port. Preferably, once the card is

plugged-in it also transmits information using the communications port. The card preferably includes a plurality of electrical contacts at one of its ends and/or a connector-sized end.

Additionally or alternatively, the card may be inserted into a CD-ROM drive or a diskette drive and obtain power from the motion of a head and/or a spinner motor. Possibly, the power is generated by friction. Additionally or alternatively, the power is obtained from the read/write energies (laser, magnetic) used by the drive. Additionally or alternatively, the card interacts with the head, for example a diskette index read head to communication with a host computer of the drive. Possibly, the card may interact (for communication purposes) with magnetic read and/or write heads even if the card is not inserted in the slot. Preferably, the card includes magnetic-field sensitive sensors, such as GMR sensors. Alternatively or additionally, the card include an RF or magnetic filed generating unit capable of affecting the read/write heads.

Additionally or alternatively, the card may be powered by inertial power, for example form movements of a person carrying the card. Additionally or alternatively, the card may include a piezoelectric power converter, possibly utilizing a same piezoelectric element as used for communication, to convert flexing of the card or varying pressure on the card (typically inadvertently) into electrical energy. Possibly, the card can be energized from ambient vibrations, such as those caused by a computer, when the card is placed on the computer.

Figs. 3B-3D are schematic illustrations of variations of smart-card structures, in accordance with preferred embodiments of the invention. In Fig. 3B., substantially all of one side of the card forms an acoustic transducer. The processor and the memory (44 and 46) are preferably embedded in the card. The battery may be a thin battery which is embedded in the card or glued on it. In one example, the card itself is manufactured of a piezoelectric material and area 42 indicates the region which is electrified using electrodes. In one embodiment, only two electrodes are used. In other embodiments, at least one of the electrodes comprises a plurality of electrodes, so that various acoustic modes may be excited and/or sensed in the card. Possibly, the two electrodes have a piezoelectric material sandwiched between them. Possibly the piezoelectric material is the card itself. In a preferred embodiment of the invention, the card is formed of a polarized plastic with piezoelectric properties. Possibly, only the portion of the card adjacent the electrodes is polarized. In some embodiments of the invention a same region 42 is used both for transmission and for reception, in others, separate regions are provided, which regions may overlap.

In a preferred embodiment of the invention, the card is electrified with an array of electrodes and these arrays may be used to detect pressure on the card, for example pressure

caused by moving a stylus over the card. Depending on the processing power of the card, this may be used as a handwriting input. Alternatively or additionally, the piezoelectric regions may be used for power supply, as indicated above. Alternatively or additionally, the piezoelectric regions my be used to generate sounds, for example recording or synthesized speech or indicator (e.g., beeps) sounds. Alternatively or additionally, the piezoelectric regions may be used as a sonic microphone, for speech input. Alternatively or additionally, the piezoelectric regions may be used to detect data input of a simpler kind, for example tapping, flexing, and/or bending of the card, or selective pressure on certain areas of the card.

In a preferred embodiment of the invention, the size and shape of the region and/or the mechanical characteristics of the card material (or at least of area 42) are selected to acoustically match the desired transmission and/or reception characteristics of the smart card. As can be appreciated, in some cases it is the card size and mechanical characteristics which determine the ultrasonic frequency to be used. Preferably, the size and thickness of the card are similar to that of a credit card. Possibly, card 40 is somewhat thicker than a credit card.

In Fig. 3C a magnetic strip doubles as a resonator 42 for piezoelectric transaction.

In Fig. 3D a holograph glued onto the card (for example as in a VISA card) serves as the ultrasonic transducer and/or to cover or contain the electronics of processor 44 and/or memory 46. In the photoelectric embodiments, above, an area 43 of the card may be embedded with photo-electric cells. Possibly, a same area is used both for photoelectric activity and for piezoelectric activity. In a preferred embodiment of the invention, card 40 includes an infra-red generating area, for example a LED 41 or a surface patch. Optionally, card 40 includes a thin-screen type display (not shown), for example an LCD display, for displaying information stored, transmitted and/or received and/or feedback.

Fig. 3E is a schematic illustration of a smart-card docking station 110 in accordance with a preferred embodiment of the invention. A smart card 112 is inserted into the reader 110. A portion 114 of the reader is configured to communicate with the smart card, for example using RF, magnetic fields, ultrasound, IR and/or any other communication protocols. Possibly, a plurality of such areas 114 are provided, each for a different physical protocol. These communications with the card are preferably transformed, using an acoustic transducer 116, into acoustic communications to be transmitted to- and/or received by- a remote computer or other electronic device, using the methods as described herein. Thus, an owner of a smart card can easily interact with a standard computer without installing a dedicated reader on the computer. Rather, the smart card owner will carry around a miniature adapter 110 which can communicate with a computer in a wireless manner.

It should be noted that although acoustic communication is preferred for at least one communication direction (computer to smart-card or smart-card computer) one or both of the communication directions may utilize other technologies, temporarily or on a permanent basis. For example, the card may use the IRDA IR communications standard or the Bluetooth RF communications standard.

In another example of the use of smart cards, a smart card is used to operate arcade games. Such a card may utilize the speaker and/or microphone of the game. Alternatively or additionally, the card may include information about the user, for example for billing. Alternatively or additionally, the information may include gaming information, for example how far in the game the player is or the player's level, so the arcade game can be suitably configured.

It should be noted that such an acoustic smart card may also be used as a customer card, as well as for an "electronic wallet", since information about the card holder can easily be retrieved from the card. Also, it is simple to transmit information to the card.

In a preferred embodiment of the invention, spatial angles between a sound source and a plurality of microphones are determined by analyzing phase differences at the microphones. Alternatively or additionally, other methods known in the art may be used. In a preferred embodiment of the invention, a relative location of a pulsing sound source and a plurality of microphones is determined by solving time of flight equations. Thus, the relative location of a smart card, an ID card (described below), an electronic device and/or a computer, relative to another electronic device, may be determined and used to control the operation and/or cooperation of one of the above electronic devices.

In a preferred embodiment of the invention, four microphones are used to determine a three-dimensional position. For a source at $r=(x_0,y_0,z_0)$ and a plurality "i" of microphones at $M_i=(x_i,y_i,z_i)$, the distances between the source and the microphones are $D_i=\|r-M_i\|$. The acoustic velocity, "c", may be known, for example based on a known velocity in air. Alternatively, it may be determined by measuring the time of flight between a sound source and a microphone having fixed and known relative locations. A difference between distances is preferably defined as $dD(i,j)=Di-Dj=c*dt(i,j)$, where $dt(i,j)$ is defined as a difference between time of arrival at microphone i and time of arrival at microphone j. For N microphones there are N-1 independent differences dD. In an optimal configuration, the four microphones located at vertexes of a tetrahedron may be used to determine the location of a source. From practical considerations, such an arrangement may not be possible. Preferably, more than four microphones are used, so that a higher resistance to noise and/or a higher localization precision may be achieved. In a preferred embodiment of the invention, the three

dimensional position is determined by numerically or analytically solving three equations of the form:

$dD=c*dt(i,j)=\|r-M_i\|-\|r-M_j\|$, where (i,j) is preferably selected to be (1,2), (2,3) and (3,4). However any other independent three pairs of microphones may be used. In some cases it is useful if one of the electronic devices operates as a transponder, which receives signals and sends back a signal indicative of the received signal and/or its time of flight.

A touch screen in accordance with a preferred embodiment of the invention utilizes acoustic transmission to detect the location of a touch implement, such as a pen. In a preferred embodiment of the invention, the position of the pen is determined using one or more microphones and/or speakers mounted on the pen, which transmit and/or receive signals from a computer and/or other speaker and/or microphone controller. Possibly, a three-dimensional position of the touch implement is determined using four acoustic elements, such as two microphones and two speakers. It is noted that a computer typically includes a modem speaker, an internal speaker and/or a keyboard speaker, as well as sound-card speakers. In addition, some computers include an ultrasonic pointing device or other ultrasonic ports. In a preferred embodiment of the invention, the smart card can communicate using this ultrasonic communication port.

In a preferred embodiment of the invention, location methods utilize a calibration process, in which the located implement is placed at one or more known location, so that it is possible to correct for the location of the speaker(s) and the microphone(s)/ Alternatively or additionally, the calibration procedure is used to correct for propagation times (of the acoustic waves and/or of electronic signals which generate sounds) and/or for reflections, wavelength dependent attenuation and/or broadband attenuation.

A different type of touch screen in accordance with a preferred embodiment of the invention detects the location of a touch implement based on the detection and position determination (2D or 3D) of sounds generated when the touch implement touches the "touch sensitive" surface.

A software protection method in accordance with a preferred embodiment of the invention comprises a passive ID tag which responds to an interrogation. In one example, such a tag is attached to the case of a software CD, such that the software will operate only if the computer on which it runs can interrogate the CD for a particular code, using ultrasonic or sonic signals. Alternatively or additionally, the ID tag may be attached to the CD itself and/or attached to (or integrated with) an implement used for interacting with the software, for example a toy implement. Alternatively or additionally, the tag may be permanently attached (such that removal will damage it) to the case and/or monitor and/or other internal or external

element of the computer. Alternatively or additionally, the ID tag is plugged in as a pass-through hasp, which possibly does not interact with the data lines which pass through it at all, but may use power from the power lines. Rather, the authentication of the software uses acoustic communication between the hasp and the microphone and/or speaker. Alternatively to protecting software, such a method may be used to protect an easily stolen device, such as a PDA or a laptop computer, which can use their internal speakers and/or microphones to detect the proximity of a required ID tag.

An authentication system in accordance with a preferred embodiment of the invention preferably uses a computer for authentication. In a preferred embodiment of the invention, a user may be authenticated by the computer dialing a user's personal communicator (for example a beeper, a cellular telephone, wireless telephone or a satellite telephone) and then listening for a ring of the personal communicator. Preferably, the personal communicator is programmed for a distinctive ring, at least for calls originating from the computer. Alternatively or additionally, a cellular network may instruct a cellular telephone to generate a certain sound, responsive to a request (possibly by computer network) from the computer.

Alternatively or additionally, a user calls up the computer (or the computer calls the user) and the computer performs authentication by transmitting a certain sound to the personal communicator and listening for that sound using its room microphone. Preferably, the sounds are sonic. Alternatively or additionally, the sounds are ultrasonic, for example 20kHz or above. In a preferred embodiment of the invention, the computer uses the detected sound to determine attributes of the personal communicator, for example its distance from the computer.

Alternatively or additionally to providing a telephone connection, a personal communicator may respond to an ambient room sound (for example an ultrasonic wave or a DTMF tone from a computer) with an ID code. Alternatively or additionally, a user may enter a code into a computer by dialing the code on his personal communicator and allowing the computer to receive the DTMF tones using the computer's microphone.

In a preferred embodiment of the invention, an authentication method uses interrogation of an ID-tag instead of a personal communicator. Possibly, the ID-tag is a smart-card. In some embodiments of the invention, such a tag is interrogated directly using RF, in others, using sound and/or ultrasound (depending on the tag construction).

Preferably, the tag responds with acoustic signals, possibly ultrasonic signals. Optionally, the tag uses the energy of the interrogation signal to generate the response signal. Alternatively or additionally, the tag is interrogated using a tag-specific code. In a preferred embodiment of the invention, such a tag is used for computer log-on authentication, for example, when a wearer approaches a computer, the computer automatically logs on to that

user. Alternatively or additionally, the computer may require the proximity of the ID card in addition to standard log-on procedures. Alternatively or additionally, the computer may periodically interrogate the ID card, to insure that the card wearer is still nearby. Alternatively or additionally, the computer may interrogate the card for user specific information, for example a voice ID or personal information. The computer can thus query the user for a voice response and compare the response (voice print and/or contents) to confirm the card wearer is a designated card wearer.

In some preferred embodiments of the invention, the card uses speech input. In others, the card detects a response to a query by the absence, quality, number and/or other features of sounds, so no real speech recognition or matching is required.

A user may wear two cards, one for general authorization and one including personal information. Thus, a computer may interrogate both cards.

In a preferred embodiment of the invention, an interrogated object receives the ultrasound signal and sends it back to a microphone of the computer. In a preferred embodiment of the invention, the computer analyses the time of flight and/or other attributes of the transmission and determines a distance from, position to, velocity of motion and/or other spatial attributes of the object.

In a preferred embodiment of the invention, the object responds immediately to the interrogation signal. Alternatively, the object delays its response to an interrogation signal, for example for a few milliseconds. Alternatively or additionally, the object transmits at a different frequency from the received frequency, for example 24kHz in response to a 20kHz query. Alternatively or additionally, the signal transmitted by the object is received by a transducer which then transmits the signal to the computer, for example acoustically or using electromagnetic coupling. Alternatively or additionally, the object may respond with an identification code. Alternatively or additionally, the object modulates its transmission with an envelope, which envelope preferable serves as an identification code and/or for transmission of information regarding a status of the object, for example a position of an arm of a toy. In some cases, the object relays information from a more remote object. In the case of identification, the object may send an ID code even without prompting from the computer, for example periodically or by a user pressing a button on the object (or by flexing the object).

In a preferred embodiment of the invention, the object amplifies the signal it receives using a discharge of a coil through a transistor, where the transistor serves as a variable resistor and/or as a wave-form controller.

In a preferred embodiment of the invention, the smart-card or the ID tag are used as a pager. In one embodiment, computers in an office can locate an ID-tag by local interrogation

and then a message may be broadcast to a nearby telephone or intercom or using a nearby computer's loudspeaker. Alternatively or additionally, a visual message may be displayed on a computer screen (which is known to be at a location at which the ID tag is located) to notify a user of the computer that the user (or somebody in the room) is being paged. In another embodiment, the computers may be used to transmit information to the smart card which will itself generate an alert to the user, for example by shaking (electrifying the piezoelectric film) or by making a sound. In another embodiment, a digital telephone network is used to generate and/or receive ultrasonic signals which can be used to communicate with a smart card. An narrow bandwidth system, for example an analog system may be used if audible sounds are used.

In a preferred embodiment of the invention, a wireless telephone system uses handsets which communicate with base stations, for example computers or telephones, using ultrasonic communication, as described herein. In a preferred embodiment of the invention, an office telephone or computer network can serve as a local cellular network for communication, by keeping track which base-stations are in communication with which handsets and by providing the ability for a base station to locate handsets and for a handset to change base stations.

Fig. 4A is a schematic illustration of an Internet transmission pathway for sounds, in accordance with a preferred embodiment of the invention. When a smart card 40 (or interrogated badge) transmits information-carrying sounds to a computer, these sounds may be analyzed on the computer. Alternatively or additionally, the sounds may be transmitted from the computer to a remote computer, where they are analyzed. In a preferred embodiment of the invention, a local client computer 62 receives sounds and transmits them over an Internet 60 to a server computer 50. Alternatively to using an Internet, an Intranet, a LAN, a Wan or another type of computer data network is used. It is noted that there exist standard protocols for transmitting sounds over networks. Thus, there is little or no need for changes in the hardware and/or software configurations of the communication pathway, especially not of client 62. The pathway can also work in the other direction, for example, when a toy downloads programming from a remote server and the programming is stored as a toy-understandable sound file, or when the server interrogates the smart card. It is noted that playing of sound is also supported by standard Internet protocols. Alternatively or additionally, a smart card may serve as an interrogated ID tag which is used to control access to and/or billing of usage of an Internet site. In one example, whenever a user requests a service from the Internet, the existence of a local smart card is ascertained. Billing information is preferably transmitted to the card. Periodically, the card is interrogated (possibly by a third party), preferably over the Internet or a telephone connection, for the existence of charges.

In an example of a financial or business interaction over an Internet, one or more of the following three levels of security may be achieved. First, the presence of the card, which can be required by local and/or by remote software. Second, confirmation of the card wearer identification using personal information. Third, an identification of the calling computer (which should preferably match the wearer profile and/or information stored on the card). Additionally, it is noted that there exist standard mechanisms for transmitting sound over an Internet, LAN, WAN or a telephone line. Thus, sonic or ultrasonic communication, for example from a smart card or an ID card may be practiced over a telephone connection or over an Internet connection. These communications may include encrypted communications, for example using RSA, DES, triple DES or TEF encoding or other public-key algorithms. Alternatively or additionally, the communication may use DTMF or DTMF-like tones. Alternatively or additionally, such communication may be used for telephone calling cards. Alternatively or additionally, such communication may be used for transmitting credit card information. In a preferred embodiment of the invention, a credit card includes a sound output (optionally encrypted). Thus, a user can "swipe" his card at any electronic device which includes a microphone (optionally a speaker, for two way communication) and suitable software/hardware, for example a home computer. Possibly, swiping software may be downloaded as a Java applet.

Generally, any type of smart card interaction, for commercial and/or for personal uses may be implemented using the acoustic transmission methods described herein.

In a preferred embodiment of the invention, a smart card is used for purchasing services and/or goods in a store. In one example, shown in Fig. 4B, a person enters into a restaurant, carrying a smart card 120. This smart card may be used for several activities in the restaurant, for example, contacting a waiter's communicator 122, selecting a free table (based on a list of tables transmitted by a central computer 124) and/or reviewing a menu and "today's specials" also transmitted by central computer 124. Possibly, some of this information and other information, such as average waiting time, current line length, average meal costs, specific dish costs, delay until a particular dish is ready, dishes which are out of stock and in general any question that a customer might ask a waiter, may even be answered when the client is outside the restaurant. The client may query for this information or it may be continuously presented. It is noted that some types of query responses require a control of details and numerical information which are beyond the ability of most waiters (but not of a central computer).

Once the customer is seated and has selected from a menu, the client can track the progress of his dish, for example by communication with a kitchen computer 132. In some

restaurants, the client is a regular customer (possibly the card is a "member's card") and the card may be used to place the order. Possibly, the client can order his "usual". Alternatively, especially if the smart card includes a display (or is implemented using a PDA) the client can order directly using the card. In some cases a card may not have a sufficient transmission range and a local transducer, such as on the table or on walls or ceilings are provided. This transducer may be replaced by a remote loudspeaker/microphone system for the central computer. In some cases, the smart card (possibly RF rather than acoustic) may be used at a distance, for example, 1, 5 10 or even 15 meters. Alternatively the card may be used at a short distance, for example, 0.5 meters or even at contact or near contact distances.

At the end of the meal, the bill total and/or the bill details are downloaded to the card. Using the card, the user can authorize payment and/or add a tip. The payment authorization is preferably transmitted by central computer 124 to a remote credit card company 126 for verification. Possibly, the smart card instructs the central computer to print out a paper slip to be signed. However, a digital-type signature is preferred. In an electronic wallet situation, no credit card company is used. Instead "cash" is withdrawn from the smart card.

In a store embodiment, or in a display-case type restaurant, the smart card may also be used to interrogate certain displays for further information, for a demonstration or for ordering.

In many situations, there will be more than one active smart card in a restaurant at a single time. In Fig. 4B a second smart card 130 is shown. In a preferred embodiment of the invention, smart cards 120 and 130 coordinate so that they do not both transit at a same time. In one example, the central computer assigns time, frequency or coding (CDMA) slots. In another example, an ALOHA algorithm is used to avoid collisions.

In a preferred embodiment of the invention, two smart cards can directly communicate, for example to exchange business information. A particular situation is at a technology show where several persons from a single company will each view part of the show and interrogate information from displays using their smart cards. At the end of the day, these persons will preferably consolidate their finding by the smart cards exchanging information or by downloading the information from the smart cards to a central computer.

Fig. 5 is a schematic block diagram of a communications tap 102 for a computer 100, in accordance with a preferred embodiment of the invention. One problem with computer communication is setting up the hardware and software for communications. In the configuration of Fig. 5, a tap is preferably placed on communication line to an existing peripheral 104. Thus, a user may not be required to even access a back part of a computer, let alone a computer's inside. A toy 106, an electronic device and/or a smart-card preferably send and/or receive signals from tap 102. Additionally or alternatively, toy 106 may use one tap for

receiving and one for sending. Possibly, a toy uses taps only for one direction of communication.

In a preferred embodiment of the invention, the tap is placed on a cable to a printer, a network cable, a camera cable and/or a SCSI connection. Additionally or alternatively, the tap is placed on a serial cable, for example a mouse cable. Additionally or alternatively, the tap is placed on a modem line, for example on a telephone line or by plugging the tap into another telephone socket, to be received by the modem. Additionally or alternatively, the tap is placed on a game controller line. Additionally or alternatively, the tap is placed on a loudspeaker line. This type of tap can detect signals which cannot be reproduced by the loudspeaker, for example very high frequencies. Additionally or alternatively, the tap is placed on a microphone line, possibly using the microphone line and/or the microphone itself as a sonic, ultrasonic or non-acoustic antenna (e.g., RF). Additionally or alternatively, the tap is placed on a display cable line.

In a preferred embodiment of the invention, the tap includes an electro-magnetic coupler, which can induce signals in a cable which passes through or near the tap. Additionally or alternatively, the tap can detect signals in the line and transmit them to toy 106. In a preferred embodiment of the invention, the signals are at a different carrier frequency and/or signal frequency than the usual signals passed along the line. Additionally or alternatively, the signals travel in an opposite direction (input signals on an output line, such as a printer or output signals on an input line, such as a mouse). Additionally or alternatively, the signals encode information which information is detected and removed from the data stream in the computer. Additionally or alternatively, the signals are asynchronic on a synchronic line. Additionally or alternatively, the signals are transmitted only when no signal is expected by the computer and/or the peripheral.

In an alternative embodiment of the invention, a piezoelectric actuator (or other vibrating element) is connected to a mouse (or a microphone). The actuator causes the mouse to shake at an amplitude of one or two screen pixels (or less) and the shaking is detected by software in the computer as signals from the toy. A return signal may be transmitted to a tap associated with the actuator, along the serial cable, with the signal preferably being coded to be recognized by the tap and/or ignored by the mouse.

In an alternative embodiment of the invention, toy 106 communicates with computer 100 using a speaker (internal and/or sound card) and/or a microphone of the computer. Preferably, toy 106 receives transmissions from the computer loudspeaker and/or sends signals to the computer microphone. Additionally or alternatively, signals are transmitted to toy 106

via the microphone and received via the loudspeaker, depending on whether the hardware supports such a reverse connection.

In an alternative embodiment of the invention, toy 106 sends signals to computer 102 using a tap which presses keys on a keyboard attached to computer 100. Preferably the key used is a shift key. Additionally or alternatively, signals from the computer are detected by detecting illumination of LEDs on the keyboard, for example a "Num Lock" LED.

Alternatively or additionally, the tap detects illumination of other LEDs on a computer, for example power, sleep, CD-ROM and/or hard disk LEDs. Alternatively or additionally, the tap detects information transmitted via noise or vibration generated by activation and/or modulation of the activity of mechanical components of the computer, for example diskette drives, disk drives and CD-ROM drives. Alternatively or additionally, the tap detects an electromagnetic signal generated by power surges to the devices, for example a CD-ROM when it is powered.

In a preferred embodiment of the invention, a tap "learns" the electromagnetic and/or acoustic profile of a particular computer and also learns the effects of various commands on this profile. When a computer desires to communicate with a tap, it preferably modifies the profile using those commands which are determined to have the greatest, most noticeable and/or fastest effect on the profile.

Additionally or alternatively, toy 106 utilizes a transducer which plugs into a parallel port, a serial port and/or is optically coupled or placed near an IR port. Preferably, the transducer is a pass-through transducer, through which a printer and/or other peripherals may communicate normally with a computer.

In a preferred embodiment of the invention, the tap and/or transducer can automatically detect which type of cable is tapped/port is connected to. Preferably, such detection is by analyzing amplitude, frequency and/or synchronization of signals passing through the lines. Additionally or alternatively, the computer detects which line is tapped, by detecting particular inferences on that line. Alternatively or additionally, software on the computer sends test signals along the lines, to be detected by the tap. Possibly, the tap can detect the signals even without being programmed with the type of line on which the signals are transmitted. Alternatively, when a tap is used, a configuration program is run so that a user can define to the tap and/or the computer what is being tapped.

In a preferred embodiment of the invention, a smart card directly taps the computer, for example using a coil embedded in the smart card to detect signals being transmitted over data lines.

In a preferred embodiment of the invention, suitable software is installed on computer 100. Preferably, the software is self installing. Preferably, the computer is not used for any other use while toy 106 is communicating with it. Additionally or alternatively, the software can differentiate between "regular" signals and signals related to the tap. In one example, a provided keyboard driver may detected special codes and/or data sequences on the keyboard line and remove them from the received data, passing only the rest of the received data to an operating system of computer 100. Additionally or alternatively, a provided mouse driver may detect spurious and/or small mouse movements, and recognize them as being tap related signals. Additionally or alternatively, a printer driver can recognize data on the cable as not coming from the printer but from a tap. Additionally or alternatively, data sent to the tap is preferably sent as data which will be rejected or ignored by the peripheral, for example having incorrect parity settings or other intentional errors. Alternatively or additionally to using a tap for communication with a toy, such a tap may be used to attach a peripheral to computer 100.

In a preferred embodiment of the invention, the signal received on the computer is used to modify a computer game and/or to generate commands to other toys, preferably using sounds generated by the computer. Thus, a computer game in which a computer display responds to external sounds, is preferably provided.

The acoustic communication may also be used to communicate between a play implement and a computer game, for example between a sword and a play-station. In one example, a light-pen or a light-gun transmits to the play-station a signal responsive to pixel intensities which are detected by a photo-detector thereon. Alternatively or additionally, a synchronization signal is transmitted from a computer and/or a set-top box to the pen, to synchronize the pixel detection with the TV raster scan. These transmissions may be additional to- or alternative to- transmission of position and/or orientation. Alternatively or additionally, the play implement transmits the status of controls thereon. Alternatively or additionally, the transmission is used to transmit information to be displayed on the implement, for example to light up lights thereon, display a number of kills thereon and/or drive text and/or graphics displays thereon.

In a preferred embodiment of the invention, a bowling game is provided, in which a computer detects sounds generated by a moving bowling ball and knocks over pins on a display. Preferably, a soft ball is used. preferably, the motion of the ball is determined relative to the computer microphone and/or speakers, as described herein. Alternatively, an independent sound generator and/or receiver may be utilized, which sound element is preferably integrated with a computer using minimally-installed hardware, as described herein.

In another example, a computer displays a thrown ball, for example a baseball and determines a "hit" based on detected motion of a baseball bat. In another example, a computer goalie attempts to stop a real ball kicked by a player. The position and/or other motion attributes of the ball are preferably determined by acoustic distance determination using only the hardware already installed in a standard computer, for example as described herein. In another example, a boxing match a computer tracks motion of a glove, to detect hits on a computer figure and/or to emulate evasive maneuvers. Alternatively or additionally, the computer tracks motion of the player, to aim its own punches and/or to asses a score. Optionally, the computer is used to display motion of a second remote player. Alternatively or additionally to boxing, the computer may track motion of sources (preferably with implanted sound devices or with a wrist band sound device). Alternatively or additionally, the computer may track positions and/or alignments of toy guns and/or of players holding the guns. Possibly a map of a room may be provided so the computer can determine if a gun has a line of site in the particular room.

In a preferred embodiment of the invention, the signals generated by a toy are inadvertently generated, for example, sounds generated by a wheel rotating or an appendage flapping. Additionally or alternatively, the signals are included in a generated action, for example, a quack sounded by a toy, which may be modulated by a signal, a blinking light, whose blinking may be modified by the signal or a waving gesture which may be modified and/or its duration or amplitude changed, to convey a signal. Additionally or alternatively, the signals are determined by analyzing a response, for example differentiating between different sounds produced by a first toy to decide which sound to make in response. Additionally or alternatively, the signal may be additional to generated actions, for example, an extra beep after a "quack". Preferably, such additional signals are made as unobtrusive as possible, for example by being ultrasonic.

In another example, a computer and/or a toy can respond to DTMF tones generated by a telephone handset, a wireless telephone, a cellular telephone or even a play telephone.

Fig. 6 is a schematic illustration of an unobtrusive computer checkup in accordance with a preferred embodiment of the invention. A user 142 is using a computer 140. A user 146 wishes to interrogate computer 140, for example to determine a networking problem. In a preferred embodiment of the invention, a smart card 144 (or other electronic device) can communicate with computer 140 using an acoustical- or a tap- channel as described above, without interfering with the activities of user 142. Alternatively or additionally, smart card 144 may be used to interrogate an interface-less device, such as a hub 148. One advantage of acoustical communication for these uses is that they do not generate a considerable amount of

RF interference and do not require major (if any) changes in a (significant) install base of hardware. In a preferred embodiment of the invention, hardware devices, such as hub 148 and computer 140 continuously "hum" their status, so that the status can be discerned by eavesdropping on the hum, without needing to interrogate the hardware.

Fig. 7 is a schematic illustration of a computer communication setup using acoustics, in accordance with a preferred embodiment of the invention. A computer 152 includes a microphone 156 which is used for detecting activity sounds of other electronic and/or mechanical devices. The activity sounds may comprise natural sounds, for example a page-sorter being used in a photocopier. Alternatively or additionally, they may comprises indicator sounds, for example a beep generated by a fax machine when a fax comes in. Alternatively or additionally, they may comprise artificial sounds, for example a special information carrying sound generated specifically for the benefit of computer 152.

In a preferred embodiment of the invention, a computer 152 transmits indications of the sensed activities to a remote computer, such as computer 154. Thus, a user at computer 154 can be informed of a fax coming in or of an unanswered telephone call even if he is in a different room and the fax machine is not connected to standard computer network.

Alternatively or additionally, the analysis of sounds detected by microphone 156 can be used to determine other occurrences at computer 152. In one example, microphone 156 can be used to log the habits of a user, including, telephone conversations, numbers dialed (by detecting the DTMF sounds), sounds of papers being shuffled, breathing sounds, snoring of a sleeping user, average number of rings until a call is answered, and typing habits. Alternatively or additionally, microphone 156 can be used to detect an occupancy of a room or glass breakage, possibly serving as a burglar alarm.

Alternatively or additionally, the microphone may be used to detect electromagnetic impulses generated by operating devices. Typically, each device has a different electromagnetic signature. Different signatures may be generated when the device is switched on or off and when the device is operated. Thus, a computer-microphone combination can be used to detect the operation of devices, such as photocopies, door chimes and computers. In a preferred embodiment of the invention, a video input card is used to analyses higher frequencies of electromagnetic radiation than those detectable by a microphone-sound card combination. It can thus be appreciated that noise signals which are usually rejected by signal processing algorithms may be analyzed to detect important ambient information.

In a particular preferred embodiment of the invention, an electronic commerce systems comprises:

(a) a computer (desktop/laptop/hand-held) with a regular microphone (built in monitor or computer or external) or special sonic/ultrasonic microphone and at least one speaker;

(b) a card or other device which has an acoustic receiver a processing unit an acoustic transmitter and input and/or output filtration and amplification circuits;

(c) a communication protocol used by the card and computer;

(d) software on the card side;

(e) software on the PC side; and

(f) a security scheme, integrated with the other components.

In the smart card, the acoustic receiver can be regular capsule microphone, or an ultrasonic type microphone, possibly specific for a particular frequency or frequency range used. The processing unit can preferably receive signals through an A/D converter and/or digital communication and can detect signal frequencies needed for the communication protocol. Preferably, the processing unit used has sufficient power (a few MIPS), and includes some (on-chip or off-chip) memory, especially for storing and/or generating a cryptographic signature. A Microchips PIC508 processing unit is preferably used and appendix "C" lists microcode for it. In some cases, special ultra-low power circuitry may be desirable. The acoustic transmitted can preferably generate a strong atmosphere wave. It is noted however, that only a small amount of power is required for short range transmissions. Additionally, the transmitter may generate waves in solids, for example to be carried by the case of the computer comprising the microphone

In a preferred embodiment of the invention, the input/output filtration circuits comprise op-amplifiers with filters for specific frequencies for input and output, dependent on the communication protocol used. If non-audible frequencies are used, the filters should decrease power in audible frequencies, to reduce annoyance of a user

The communication protocol is preferably a digital binary code in which the bits are transmitted using Frequency Modulation, Pulse Width Modulation, On-Off Keying and/or any combination of the above. Error correction codes, for example parity, Gray or Hamming codes, as known in the art may be used. It should be noted that the range of available frequencies may be limited if ultrasonic frequencies are used, due to degraded capabilities of the computer sound card.

An exemplary software for the smart card is provided as an appendix "C" attached herewith. This software demodulate the signals received and convert them to data bits, either by time domain analysis or by Fourier analysis. Thereafter, error checking is preferably performed. The received information may be decrypted (if necessary). Alternatively or additionally, the received information may be encrypted, verified and/or signed, in order to be

stored in local memory. The local memory may comprise ROM, RAM, EPROM, EPROM and/or other types of memory as known in the art. Information to be transmitted may be encrypted before transmission.

An exemplary software for the PC, written in Visual Basic version 6.0 and in Delphi version 4.0 (a DLL) is provided as an appendix "A" and an Appendix "B" respectively, attached herewith. This software receives a detected signal, filters it, and opens the protocol. Preferably, the software checks for errors using IIR Band Pass and/or low pass filters.

The received and filtered signal is then demodulated, into data bits, for example, by time domain analysis or by Fourier analysis. Data transmission errors are preferably corrected. The data may then be locally analyzed and/or transmitted to a remote location, for example a seller's computer. In some embodiments, this software is written in an Internet Language, such as Java or ActiveX.

In a preferred embodiment of the invention, the acoustical detection uses the maximum resolution and/or sensitivity afforded by the microphone, i.e., going below the noise threshold as defined for audio uses. Alternatively or additionally, repeating and/or periodic ambient sounds are detected and removed or disregarded from the input signal. In a preferred embodiment of the invention, ambient sounds are characterized as such during a calibration step which may be performed periodically.

In a preferred embodiment of the invention, the following security scheme is used: the card has stored thereon a private key of owner. A facilitator has public keys of all users and is accessible via an Internet or other means. In some cases the seller is also the facilitator.

In an exemplary embodiment, a user connects to a seller's site, decides on a purchase and when he is done he activates the card which in turn signals a local computer to transmit purchasing data (e.g., a catalog number) and a random number, back to the card. The card in return, signs on the data and the number with its private key and sends the signature back to the computer. The computer receives the signature and sends it to the seller. The seller then verifies the signature, for example using a locally stored public key or with the help of the facilitator. The supplier may save the purchasing data and signature for his proof of purchase. The facilitator can also server to check if the random numbers are really random or to supply such random numbers.

This scheme can use any cryptographic method for electronic signature, for example RSA or methods which are not based on public/private keying.

In some embodiments, the card is used only for transmission of a purchase authorization, possibly without receiving any data from the computer. possibly, such information is entered directly into the card, for example using buttons on the card.

Alternatively, the card only transmits a "usage" authorization, which is unrelated to the particular purchase. Such an authorization is preferably a one-time, temporally limited authorization, which expires after a short time, for example 30 seconds. In one such exemplary embodiment, the card sends information using frequency modulations and using a start and a stop bit. A synchronization byte is preferably sent in the beginning of transmission. Replies from the seller may be locally stored on the computer for use by the card owner.

In a preferred embodiment of the invention, the seller and/or the facilitator can download advertisements and/or operating instructions to the smart card, possibly as part of a purchase agreement. This is especially useful in toys which are programmed using sounds downloaded from the Internet. Some of the downloaded sounds may comprise an audio (or visual - for suitable toys) user manual.

Figs. 8A and 8B comprise an electronic schematic of a smart card in accordance with a preferred embodiment of the invention. A brief explanation follows:

The reception of a signal is via a miniature wide band microphone, and the transmission is via a low profile miniature diaphragm. The sound frequencies are in the range of 18 kHz to 22 kHz, in order to make the data transfer inaudible. However, lower (audible) frequencies can be used when the computer microphone has a poor performance, or when otherwise desirable.

Fig. 8B describes a receiver circuit including a narrow band amplifier, with an Automatic Gain Control (AGC). U1B provides reference DC voltage for the whole analog subsystem. U1A is a preamplifier for a miniature wideband microphone X1, with a gain of 38db. A coil L1 is part of a resonator with a Q factor of 4. U2A and U2B form an AGC through a JFET transistor Q1. The AGC provides variable gain in the range of 0db to 26db.

The circuit detects an audio signal in the relevant band, and then compensates the gain by the AGC to form a stable output signal with amplitude of approximately 2Vpp. The AGC needs a maximum time of 4 mSec to stabilize the gain. This time constant is controlled by the value of R10. After reaching the desired level, it changes it with a slow time constant of 1sec, which is determined by the value of R12.

The analog signal is then fed into a comparator U3, which produces a square wave with the frequency of the analog signal. This signal can be processed digitally by microcontroller U4. The analog signal can also be digitized by an A/D for more accurate processing in a more sophisticated microprocessor.

Fig. 8A shows a transmitting circuit. A speaker SP1 produces the transmission. It is driven by a FET U5. A capacitor C18 is charged to full voltage after approximately 1mSec,

allowing small amplitude of speaker driving signal at ignition, in order to make the signal inaudible.

A part listing follows:

Item	Part	Reference	Note
1	0.1uF	C12	
2	0.1uF	C13	
3	0.1uF	C15	
4	0.1uF	C16	
5	0.1uF	C17	
6	0.1uF	C19	
7	1.5K	R20	
8	1.5mHy	L1	
9	1K	R9	
10	1M	R12	
11	1uF	C8	
12	5K	R19	
13	5K	R17	
14	10K	R10	
15	10nF	C7	
16	10nF	C9	
17	10nF	C10	
18	10uF	C11	
19	10uF	C14	
20	10uF	C18	
21	39K	R1	
22	39K	R2	
23	39K	R15	
24	47K	R6	
25	47K	R8	
26	47K	R16	
27	47nF	C4	
28	50pF	C6	
29	100K	R5	
30	100K	R11	
31	100K	R13	
32	100K	R14	
33	100K	R21	
34	100pF	C1	
35	100	R18	
36	150K	R7	
37	150pF	C2	
38	150pF	C5	
39	750	R3	
40	750	R4	
41	7916J-001--001	S1	miniature switch
42	.22uF	C3	
43	BATTERY	BT1	low profile battery
44	BATTERY	BT2	low profile battery

45	X1	EK-3032	miniature wideband microphone
46	FT-12T	LS1	low power high frequency diaphragm
47	KN01P3ASAQ		
48	LED-DUAL		
49	LM6142	U1A	low current wideband amplifier
50	LM6142	U1B	low current wideband amplifier
51	LM6142	U2A	low current wideband amplifier
52	LM6142	U2B	low current wideband amplifier
53	MAX986	U3	low current high slew rate comparator
54	MBR0530T1	D1	low Vf low leakage current diode.
55	MBR0530T1	D2	low Vf low leakage current diode.
56	MBR0530T1	D4	low Vf low leakage current diode.
57	MBR0530T1	D5	low Vf low leakage current diode.
58	PIC12C509	U4	microcontroller
59	SST177	Q1	JFET
60	Si3454DV	U5	low Rds FET

The present invention has been described in terms of preferred, non-limiting embodiments thereof. It should be understood that features described with respect to one embodiment may be used with other embodiments and that not all embodiments of the invention have all of the features shown in a particular figure. In particular, the scope of the invention is not defined by the preferred embodiments but by the following claims. Section titles, where they appear, are not to be construed in limiting subject matter described therein, rather section titles are meant only as an aid in browsing this specification. When used in the following claims, the terms "comprises", "comprising", "includes", "including" or the like means "including but not limited to".

CLAIMS

1. A method of communicating with an electronic device, comprising:

providing a computer having a sound receiving and generating sub-system including a microphone;

transmitting from a source at least one ultrasonic acoustic signal, encoded with information to the computer; and

receiving said at least one signal by said microphone, to be detected by said computer.

2. A method of communicating with an electronic device, comprising:

providing a computer having a sound receiving and generating sub-system including a microphone and a loudspeaker;

transmitting from a source at least one acoustic signal, encoded with information to the computer;

receiving said at least one signal by said microphone, to be detected by said computer; and

transmitting to said source, using said loudspeaker, at least a second acoustic signal, encoded with information, in response with said detected signal.

3. A method according to claim 2, wherein at least one of said at least one signal and at least a second signal comprise an ultrasonic signal.

4. A method of communicating with an electronic device, comprising:

providing an electronic device having a sound receiving and generating sub-system including a microphone and a loudspeaker;

transmitting from a source at least one ultrasonic acoustic signal, encoded with information to the electronic device;

receiving said at least one signal by said microphone, to be detected by said electronic device; and

transmitting to said source, using said loudspeaker, at least a second ultrasonic acoustic signal, encoded with information, in response with said detected signal.

5. A method according to claim 4, wherein said electronic device comprises a computer.

6. A method of communicating with an electronic device, comprising:

providing a telephone having a sound receiving and generating sub-system including a microphone;

transmitting from a source at least one acoustic signal, encoded with information to the telephone; and

receiving said at least one signal by said microphone, to be used locally by said telephone.

7. A method according to claim 6, wherein said acoustic signal comprises an ultrasonic signal.

8. A method of communicating with an electronic device, comprising:

providing a computer having a sound receiving and generating sub-system including a microphone;

transmitting from a source at least one acoustic signal, encoded with information to the computer; and

receiving said at least one signal by said microphone; and

forwarding an indication of said information to a remote computer, over an Internet.

9. A method according to claim 8, wherein said indication comprises a sound file.

10. A method according to claim 8, wherein said indication comprises a data file.

11. A method according to any of claims 8-10, wherein said acoustic signal comprises an ultrasonic signal.

12. A method according to any of claims 1,2,3,5 or 8-11, wherein said computer comprises a PDA (personal data assistant).

13. A method according to any of claims 1,2,3,5 or 8-11, wherein said computer comprises a portable computer.

14. A method according to any of claims 1,2,3,5 or 8-11, wherein said computer comprises a desk-top computer.

15. A method according to any of claims 1,2,3,5 or 8-14, comprising processing said at least one sound by said computer.

16. A method according to claim 15, wherein processing comprises extracting said encoded information.

17. A method according to claim 15 or claim 16, wherein said processing comprises determining a distance between said microphone and said source.

18. A method according to any of claims 15-17, wherein said processing comprises determining movement of said microphone relative to said source.

19. A method according to claim 18 wherein said movement comprises angular movement.

20. A method according to claim 18 or claim 19, wherein said movement comprises translation.

21. A method according to any of claims 15-17, wherein said processing comprises determining a spatial position of said microphone relative to said source.

22. A method according to claim 21, wherein said spatial position is a one-dimensional spatial position.

23. A method according to claim 21, wherein said spatial position is a two-dimensional spatial position.

24. A method according to claim 21, wherein said spatial position is a three-dimensional spatial position.

25. A method according to any of claims 15-24, wherein said processing comprises emulating a touch screen using said received at least one sound.

26. A method according to any of claims 15-24, wherein said processing comprises emulating a pointing device using said received at least one sound.

27. A method according to any of claims 15-24, comprising controlling at least one action of a toy, responsive to said received at least one sound.

28. A method according to claim 5 or claim 6, wherein said any of claims 1-15, wherein said electronic device comprises a wireless communication device.

29. A method according to claim 4, wherein said electronic device comprises a computer.

30. A method according to claim 4, wherein said electronic device comprises a computer peripheral.

31. A method according to claim 30, wherein said peripheral comprises a printer.

32. A method according to claim 4, wherein said device comprises a toy.

33. A method according to claim 32, wherein said information comprises programming information.

34. A method according to claim 32, wherein said information comprises music.

35. A method according to any of claims 1-34, wherein said source comprises a toy.

36. A method according to claim 35, wherein said information comprises stored player input.

37. A method according to any of claims 1-34, wherein said source comprises a smart card.

38. A method according to any of claims 1-34, wherein said source comprises a wireless communication device.

39. A method according to any of claims 1-34, wherein said source comprises a computer.

40. A method according to any of claims 1-34, wherein said source comprises a computer peripheral.

41. A method according to any of claims 1-40, comprising performing a financial transaction responsive to said at least one transmitted signal.

42. A method according to any of claims 1-41, comprising identifying a person responsive to said at least one transmitted signal.

43. A method according to any of claims 1-42, wherein said information comprises personal information.

44. A method according to any of claims 1-43, comprising logging into a computer system responsive to said at least transmitted signal.

45. A method according to any of claims 1 or 6-11, comprising transmitting at least a second acoustical signal responsive to said received at least one signal.

46. A method according to any of claims 2 or 5-10, wherein said acoustic signal comprises human audible sound.

47. A method according to claim 46, wherein said sound has a main frequency over 10kHz.

48. A method according to any of claims 2 or 5-10, wherein said sound has a main frequency which is infra-sonic.

49. A method according to any of claims 1-48, wherein said information is encoded using below human-threshold amplitude.

50. A method according to any of claims 1-48, wherein said information is encoded using below human-threshold amplitude variations.

51. A method according to any of claims 1-50, wherein said sound is generated at a frequency outside a normal operating frequency for said sound subsystem.

52. A method according to any of claims 1-51, wherein said sound subsystem is designed for generating musical sounds.

53. A method according to any of claims 1-52, wherein said sound subsystem comprises a sound card.

54. A method according to claim 53, wherein said sound card comprises a SoundBlaster compatible sound card.

55. A method according to any of claims 1-54, wherein said sound-sub-system is designed for communication with a human operator.

56. A method according to any of claims 1, 3, 4 or 11, wherein said ultrasonic signal has a main frequency below 50kHz.

57. A method according to any of claims 1, 3, 4 or 11, wherein said ultrasonic signal has a main frequency below 35kHz.

58. A method according to any of claims 1, 3, 4 or 11, wherein said ultrasonic signal has a main frequency below 25kHz.

59. A method according to any of claims 1, 3, 4 or 11, wherein said ultrasonic signal has a main frequency of about 24kHz.

60. A method according to any of claims 1, 3, 4 or 11, wherein said ultrasonic signal has a main frequency of about 22kHz.

61. A method according to any of claims 1, 3, 4 or 11, wherein said ultrasonic signal has a main frequency of about 20kHz.

62. A method according to any of claims 1, 3, 4 or 11, wherein said ultrasonic signal has a main frequency of below 20kHz.

63. A method of performing a transaction over an Internet, comprising:

transmitting information encoding acoustic waves over the Internet from a client computer to a server computer;

analyzing said information at said server computer; and

performing a transaction at said server computer responsive to said analysis.

64. A method according to claim 63, comprising inputting said acoustic waves to said client computer using a microphone of said client computer.

65. A method according to claim 63 or claim 64, wherein said transaction comprises a financial transaction.

66. A method according to any of claims 63-65, wherein said information comprises authentication information.

67. A method according to any of claims 63-66, wherein said waves comprise ultrasonic waves.

68. A method of creating a smart card terminal, comprising:

providing a general purpose computer having a general-purpose sound sub-system; and

loading a smart-card terminal software on said computer,

wherein said software controls said sound system to receive acoustic waves from a smart card.

69. A method according to claim 68, wherein said software analyses said received acoustic waves to determine information encoded by said acoustic waves.

70. A method according to claim 68, wherein said software retransmits said acoustic waves to a remote computer which analyses said received acoustic waves to determine information encoded by said acoustic waves.

71. A method according to any of claims 68-70, wherein loading a smart-card terminal software comprises downloading the software over an Internet.

72. A method according to any of claims 68-71, wherein said acoustic waves comprise ultrasonic waves.

73. A smart card comprising:

a memory;

a processor; and

an ultrasonic transmitter which transmits signals generated by said processor responsive to information stored in said memory, wherein said signals have a main frequency of under 30kHz.

74. A smart card according to claim 73, comprising a receiver which receives ultrasonic signals, wherein said processor processes said received signals and stores information in said memory responsive to said processing.

75. A smart card according to claim 73 or claim 74, wherein at least one of said transmission and reception are encrypted using a public-key encryption scheme.

76. A computer system comprises:

a processor;

a sound sub-system, designed for generating music, comprising:

a speaker which generates acoustic waves; and

a microphone which receives acoustic waves;

a memory; and

a software installed in said memory, wherein said software analyses acoustic waves received by said microphone to recognize information encoded by said acoustic waves and wherein said software uses said speaker to transmit information encoding acoustic waves responsive to said recognized information.

77. A computer according to claim 76, wherein said acoustic waves comprise ultrasonic acoustic waves.

78. A method of Internet authentication, comprising,

transmitting, over an Internet, authentication information encoded by sound, from a client computer to a server computer;

analyzing said information at said server computer; and

transmitting, over the Internet, an authentication response to said client computer.

79. A method of attaching a peripheral to a computer, comprising:

providing a general purpose computer including a sound generating and receiving subsystem;

analyzing, at said computer, received sounds to detect acoustic transmissions from said peripheral; and

transmitting, form said computer, information to said peripheral using encoded sound transmissions.

80. A method of consumer transactions, comprising:

wireless receiving in a commercial institution, from a remote computer located in the commercial institution, a bill;

authorizing said bill; and

transmitting said authorization to said remote computer.

81. A method according to claim 80, wherein said commercial institution comprises a restaurant.

82. A method according to claim 80 or claim 81, comprising adding an amount to said bill.

83. A method of power transmission to a smart card, comprising:

transmitting an ultrasonic wave to a smart card;

converting said wave to electrical energy at said smart card;

storing said energy at said smart card; and

using said electrically stored energy to power a transmission from said smart card.

84. A method according to claim 83, wherein said wave is converted using a same piezoelectric transducer as used for said transmission.

ABSTRACT OF THE INVENTION

Communication between electronic devices using sonic or ultrasonic waves without requiring the installation of dedicated communication hardware in the devices. Preferably, the communication uses existing speakers and/or microphones that are usually included in a computer installation for generating music for a human user.

Appendix A

VisualBasic Code for Computer

```
Attribute VB_Name = "main"
Option Explicit

'Signal params
Public Const MINAMP As Integer = 300
Public Const MinQWidth As Long = 400 '>10*(2*20)samples per bit
Public Const periodorg As Long = 100 'length in samples of two bits = 2* fsample/freq
Public Const ftimeorg As Long = 60
Public Const rtimeorg As Long = 40
Public Const NSYNC As Integer = 5        '# of ['1','0'] repetitions in beginning for sync (5=1 byte)
Public Const SigDuration As Long = 200 'in msec (should be 200 for full visa)
                    'used to determine recording time.
Public Const MAXRECIEVEDBITS As Long = 1000 'used only for result array allocation
'Public Const IDEALSTRING As String = "W5326100311229999"
Public Const IDEALSTRING As String = "Comsense Ltd. 1234"

'Public Const FileName As String = "K:\ecom\m\data2.wav"
Public Const FileName As String = "mic"
Public Const MaxFileDataLength As Long = 44100
Public Type minmaxstruct
  Val As Integer
  loc As Long
End Type
Public Data() As Integer, Dataorg() As Integer, t As Single

 Sub test()

 Dim maxorg As Integer, minorg As Integer, rtime As Long, ftime As Long, stopbitloc As Long, errmsg As String
   Dim result() As Integer, resultd() As Integer, ideal() As Integer, diff() As Integer, msg As String
   ReDim result(MAXRECIEVEDBITS)
   ReDim resultd(MAXRECIEVEDBITS)
   Call GetSyncData(stopbitloc, minorg, maxorg, rtime, ftime)
   Call GetData(stopbitloc, minorg, maxorg, rtime, ftime, errmsg, result, resultd)
   ideal = char2bin(IDEALSTRING)
   diff = CompareVecs(ideal, resultd)
   graph.MSChart1.ChartData = diff
   'msg = bin2char(resultd)
 End Sub

 Sub mainfunc()

  Dim FoundSignal As Boolean, i As Integer, temp() As Integer
  Dim maxorg As Integer, minorg As Integer, rtime As Long, ftime As Long
```

```
Dim stopbitloc As Long, errmsg As String, msg As String
Dim result() As Integer, resultd() As Integer, ideal() As Integer, diff() As Integer
'%-int,&-long int,!-single float,#-double

FoundSignal = False
graph.show
ReDim result(MAXRECIEVEDBITS)
ReDim resultd(MAXRECIEVEDBITS)
ideal = char2bin(IDEALSTRING)
While FoundSignal = False
  Debug.Print "—————————————————"
  tic
again:
  Call preprocess
  toc ("preproc")
  FoundSignal = Get_Data_From_Signal(MINAMP, MinQWidth)
  Call Plot(1, Dataorg, 15)
  Call Plot(2, Data, 15)
  'i = DoEvents()
  'toc ("graphs")
  'GoTo again
  'graph.MSChart1.ChartData = Dataorg
  'graph.MSChartzoom.ChartData = Data
  If FoundSignal = True Then
    Call GetSyncData(stopbitloc, minorg, maxorg, rtime, ftime)
    FoundSignal = GetData(stopbitloc, minorg, maxorg, rtime, ftime, errmsg, result, resultd)
    If FoundSignal = True Then
       diff = CompareVecs(ideal, resultd)
       Call Plot(2, Data, 1)
       Call Plot(3, diff, 1)
       'msg = bin2char(resultd)
     Else
       ReDim diff(2) ' plot triangle for bad stop/start
       diff(1) = 1
       diff(2) = 0
       Call Plot(3, diff, 1)
       graph.counter.Caption = graph.counter.Caption + 1
     End If
  End If
  i = DoEvents()
  FoundSignal = False
 Wend
End Sub

Sub tic()
  t = Timer
End Sub

Sub toc(s)
  Debug.Print s; " = "; Timer - t
  graph.time.Caption = Timer - t
  t = Timer
```

```
End Sub

---------------------------------------------

Attribute VB_Name = "functions"
Sub preprocess()
   Dim Fd(2, 3) As Single, Flp(2, 3) As Single

   Call InitFilt(Fd, Flp)
   Call Read_Data_From_File(FileName)
   Call MATLABFiltFast(Fd)
   Call DataAbs
   Call MATLABFiltFast(Flp)
   'Call MATLABFiltFast(Flp)
   Call SavedataAsOrg
   'graph.MSChart1.ChartData = Dataorg
   'graph.MSChartzoom.ChartData = Data
End Sub

Sub Plot(figurenum As Integer, source() As Integer, decimate As Integer)
   Dim temp() As Integer, i As Long, j As Long
   ReDim temp(Int(UBound(source) / decimate))
   For i = 1 To UBound(temp)
      temp(i) = source(i * decimate)
   Next
   If figurenum = 1 Then
      graph.MSChart1.ChartData = temp
   ElseIf figurenum = 2 Then
      graph.MSChart2.ChartData = temp
   ElseIf figurenum = 3 Then
      graph.MSChartzoom.ChartData = temp
   End If
End Sub
Sub MATLABFilt(Filt)
   Dim temp() As Integer, FiltLength
   Dim i, j As Integer

   FiltLength = UBound(Filt) + 1
   ReDim temp(DataLength)
   For i = 1 To DataLength
      temp(i) = Filt(2, 1) * Data(i)
      For j = 2 To FiltLength
         If (j <= i) Then
            temp(i) = temp(i) + Filt(2, j) * Data(i + 1 - j)
            temp(i) = temp(i) - Filt(1, j) * temp(i + 1 - j)
         End If
      Next j
   Next i
   For i = 1 To DataLength
      Data(i) = temp(i)
```

```
  Next i
End Sub

Sub MATLABFiltFast(Filt)
  Dim temp() As Integer
  Dim i As Long, L As Long

  L = UBound(Data)
  ReDim temp(L)
  For i = 3 To L
    temp(i) = (Filt(2, 1) * Data(i) + Filt(2, 2) * Data(i - 1) + Filt(2, 3) * Data(i - 2) - Filt(1, 2)
* temp(i - 1) - Filt(1, 3) * temp(i - 2))
  Next i
  For i = 1 To L
    Data(i) = temp(i) 'CSng(temp(i)) / 1.5
  Next i
End Sub
Sub DataAbs()
  Dim i As Long

  For i = 1 To UBound(Data)
    Data(i) = Abs(Data(i))
  Next
End Sub

Function Read_Data_From_File(FileName)

  Dim fin
  Dim i As Long, nsamples As Long

  If StrComp(FileName, "MIC") = 1 Then 'read from mic'
    nsamples = RecordSampleRate * RecordTime / 1000 * 2 'for two mics
    ReDim Data(nsamples * 2) 'in bytes
    Call DoToneTobuff(Action, RecordSampleRate, Playfreq, PlayTime, Speaker, _
        Delay, RecordSampleRate, Int(RecordTime), Data(1), _
        nsamples * 2 - 1)
    For i = 1 To Int(nsamples / 2)
      Data(i) = Data(i * 2)
    Next
    ReDim Preserve Data(Int(nsamples / 2))
  Else 'Reading from File
    nsamples = MaxFileDataLength
    ReDim Data(nsamples)
    fin = FreeFile()
    Open FileName For Binary As fin
    Get fin, 101, Data
    Close fin
  End If

End Function
Sub SavedataAsOrg()
  Dim i As Long
```

```
  ReDim Dataorg(UBound(Data))
  For i = 1 To UBound(Data)
   Dataorg(i) = Data(i)
  Next
End Sub

Sub InitFilt(Fd() As Single, Flp() As Single)
  Fd(1, 1) = 1#
  Fd(1, 2) = 1.6743
  Fd(1, 3) = 0.7483

  Fd(2, 1) = 0.1259 / 1.5
  Fd(2, 2) = 0# / 1.5
  Fd(2, 3) = -0.1259 / 1.5

  Flp(1, 1) = 1#
  Flp(1, 2) = -1.7991
  Flp(1, 3) = 0.8175

  Flp(2, 1) = 0.0046
  Flp(2, 2) = 0.0092
  Flp(2, 3) = 0.0046
End Sub


----------------------------------------------

Attribute VB_Name = "functions2"
Function GetData(stopbitloc As Long, minorg As Integer, maxorg As Integer, rtime As Long,
ftime As Long, _
        errmsg As String, result() As Integer, resultd() As Integer) As Boolean
  Dim i As Long, j As Long, temp As Integer, starthigh As Integer, stoplow As Integer
  Dim goodsig As Boolean, endreached As Boolean, ires As Long
  Dim min As Integer, max As Integer, high As Integer, low As Integer, radius As Long
  Const a As Single = 0.8
  temp = UBound(resultd) """"
  goodsig = True
  endreached = False
  max = maxorg
  min = minorg
  i = stopbitloc - 10
  radius = 5
  ires = 1 'results array index
  While goodsig = True And endreached = False
    If i > 3500 Then
      i = i
    End If

    If (i + 10.5 * (rtime + ftime)) > UBound(Data) Then
      endreached = True
    Else
      'find next bit starting position and levels
```

```
min = min * a + (1 - a) * FindMinMax(i - ftime * 0.2, rtime * 1.2, 0).Val
max = max * a + (1 - a) * FindMinMax(i - ftime * 0.2, rtime * 1.2, 1).Val
high = (max + min) / 2 + (max - min) / 2# * 0.1 '%%%
low = (max + min) / 2 - (max - min) / 2# * 0.1 '%%%
starthigh = (max + min) / 2
stoplow = (max + min) / 2
j = i '+ rtime * 0.2
temp = Data(j)
While temp < (high + low) / 2# And j < i + rtime '* 0.8
  j = j + 1
  temp = Data(j)
Wend
i = j + rtime * 0.5 - 10 '%%%
'now we are at the location of the start bit
'check start bit
temp = getpoint(Data, i, radius)
If temp < starthigh Then
goodsig = False
errmsg = "bad start bit at" '+num2str(j)
Else
For j = 1 To 8
  If (j - Int(j / 2) * 2) = 1 Then 'j is odd
    i = i + ftime
  Else
    i = i + rtime 'even'
  End If
  If UBound(Data) < i Then
    goodsig = False
    errmsg = "end of signal reached in the middle of byte"
  Else
    result(ires) = getpoint(Data, i, radius)
    If result(ires) >= high Then
      resultd(ires) = 1
    ElseIf resultd(ires) <= low Then
      resultd(ires) = 0
    Else
      resultd(ires) = 5
    End If
    ires = ires + 1
  End If
Next j
'check stop bit
i = i + ftime
temp = getpoint(Data, i, radius)
If temp > stoplow Then
  goodsig = False
  errmsg = "bad stop bit at location " '+num2str(j)
End If
End If
End If
Wend
If goodsig = False Then
```

```
      goodsig = False
    Else
      ReDim Preserve resultd(ires - 1)
      ReDim Preserve result(ires - 1)
    End If
    graph.errmsg.Text = errmsg
    GetData = goodsig
End Function
Function getpoint(Data() As Integer, i As Long, radius As Long) As Integer
    Dim sum As Single, j As Long
    'do average
     'sum = 0
     'For j = i - radius To i + radius
     '    sum = sum + Data(j)
     'Next
     'getpoint = sum / (2 * radius + 1)
    'or without average
     getpoint = Data(i)
End Function

Function CompareVecs(ideal() As Integer, received() As Integer)
    Dim i As Long, temp() As Integer, errstr As String
    Dim li As Long, lr As Long, L As Long
    lr = UBound(received)
    li = UBound(ideal)
    L = li
    If lr <> li Then
       errstr = "ERROR IN COMPARISON: BAD LENGTHS"
       If lr > li Then
          errstr = errstr + " Received " + Str(lr - li) + " more bits"
          L = li
       Else
          errstr = errstr + Str(li - lr) + "bits are missing"
          L = lr
       End If
       graph.errmsg.Text = errstr
       ReDim temp(L)
       For i = 1 To L
          temp(i) = ideal(i) - received(i)
       Next
    End If
    CompareVecs = temp
End Function

Function Get_Data_From_Signal(MINAMP As Integer, MinQWidth As Long)
    Dim i As Long, istart As Long, iend As Long
    Dim QuietPeriod As Integer, FoundQuiet As Boolean, FoundSignal As Boolean
    Dim temp() As Integer, MARGIN As Integer

    BEGINMARGIN = 20
    ENDMARGIN = 100
    FoundQuiet = False
```

```
FoundSignal = False
QuietPeriod = 0
i = 1
While i <= UBound(Data, 1) And FoundQuiet = False 'wait for quiet period
  If (Data(i) < MINAMP) Then
    QuietPeriod = (QuietPeriod + 1
  Else
   QuietPeriod = 0
  End If
  i = i + 1
  If QuietPeriod >= MinQWidth Then
   FoundQuiet = True
  End If
Wend
If FoundQuiet = True Then 'wait for Signal
  While i <= UBound(Data, 1) And FoundSignal = False
   If (Data(i) > MINAMP) Then
     istart = i - BEGINMARGIN
     FoundSignal = True
   End If
   i = i + 1
  Wend
End If
If FoundSignal = True Then 'wait for 2nd quiet period
  QuietPeriod = 0
  FoundQuiet = False
  While i <= UBound(Data, 1) And FoundQuiet = False
   If (Data(i) < MINAMP) Then
     QuietPeriod = QuietPeriod + 1
   Else
     QuietPeriod = 0
   End If
   i = i + 1
   If QuietPeriod >= MinQWidth Then
     FoundQuiet = True
   End If
  Wend
  If FoundQuiet = True And (i - istart) > _
  (RecordSampleRate / 1000 * SigDuration) Then 'we found a signal
   iend = i - MinQWidth + ENDMARGIN
   ReDim temp(iend - istart + 1)
   For i = istart To iend 'copy the file data to new array
      temp(i - istart + 1) = Data(i)
   Next
   'copy back to Data array
   ReDim Data(iend - istart + 1)
   For i = 1 To UBound(temp)
      Data(i) = temp(i)
   Next
   FoundSignal = True
  Else
   FoundSignal = False
```

```
    End If
  End If
  Get_Data_From_Signal = FoundSignal
End Function

Function GetSyncData(stopbitloc As Long, minorg As Integer, maxorg As Integer, rtime As
Long, ftime As Long)
' returns high and low average values and risetime,falltime in # of bits.
Dim max(NSYNC) As Long, min(NSYNC) As Long, i As Integer, minmax As minmaxstruct
Dim Maxloc(NSYNC) As Long, Minloc(NSYNC) As Long, rtimearr(NSYNC - 1) As Long,
ftimearr(NSYNC) As Long
Dim temp As Integer
For i = 1 To NSYNC '5
 'find max
 minmax = FindMinMax(1 + (i - 1) * periodorg, periodorg, 1)
 max(i) = minmax.Val
 Maxloc(i) = minmax.loc
 minmax = FindMinMax(1 + (i - 1) * periodorg + ftimeorg, periodorg, 0)
 min(i) = minmax.Val
 Minloc(i) = minmax.loc
Next

 minorg = average(min)
 maxorg = average(max)

 For i = 1 To NSYNC
  ftimearr(i) = Minloc(i) - Maxloc(i)
 Next
 For i = 1 To NSYNC - 1
  rtimearr(i) = Maxloc(i + 1) - Minloc(i)
 Next

 ftime = average(ftimearr)
 rtime = average(rtimearr)
 stopbitloc = Minloc(NSYNC)

 End Function

Function average(x() As Long) As Long
  Dim i As Long, temp As Long
  temp = 0
  For i = 1 To UBound(x)
    temp = temp + x(i)
  Next
  temp = temp / UBound(x)
  average = temp
End Function


Function FindMinMax(istart As Long, deltai As Integer, MinORMax As Byte) As
minmaxstruct
'finds min(0)/max(1) in Data from point istart with deltai samples
```

```
Dim i As Long, temploc As Long, tempval As Integer
tempval = Data(istart)
For i = istart To istart + deltai
 If MinORMax = 1 And tempval < Data(i) Then 'MAX
                    tempval = Data(i)
                    temploc = i
                    End If
 If MinORMax = 0 And tempval > Data(i) Then 'MIN
                    tempval = Data(i)
                    temploc = i
                    End If
Next i
FindMinMax.Val = tempval
FindMinMax.loc = temploc
End Function
Function char2bin(s As String) 'converts ascii values to binary vector msb to lsb
  Dim i As Long, j As Integer
  Dim result() As Integer, temp As Integer
  ReDim result(Len(s) * 8)
  For i = 1 To Len(s)
    temp = Asc(Mid(s, i, 1))
    For j = 8 To 1 Step -1
      result((i - 1) * 8 + j) = temp - Int(temp / 2) * 2
      temp = Int(temp / 2)
    Next
  Next
  char2bin = result
End Function

Function bin2char(Binary As Integer) As String
'converts binary data to Chars
Dim Counter1 As Long, Counter2 As Integer, Counter3 As Integer
Dim Convertor() As Integer, temp() As Integer

ReDim temp(Int(Len(Binary) / 8))
ReDim Convertor(Len(Binary))
Counter3 = 1
For Counter1 = 1 To 8 * Int(Len(Binary) / 8) Step 8
  For Counter2 = Counter1 To Counter1 + 7
    Convertor(Counter2) = Val(Mid$(Binary, Counter2, 1))
  Next Counter2
  temp(Counter3) = Convertor(Counter1) * 128 + Convertor(Counter1 + 1) * 64 + _
          Convertor(Counter1 + 2) * 32 + Convertor(Counter1 + 3) * 16 + _
          Convertor(Counter1 + 4) * 8 + Convertor(Counter1 + 5) * 4 + _
          Convertor(Counter1 + 6) * 2 + Convertor(Counter1 + 7) * 1
  bin2char = bin2char + Chr$(temp(Counter3))
  Counter3 = Counter3 + 1
Next Counter1
End Function
```

Appendix B

Delphi Code for ToneDLL

TESTFRM.PAS

```
unit testfrm;

interface

uses
  Windows, Messages, SysUtils, Classes, Graphics, Controls, Forms, Dialogs,
  StdCtrls{, tonefrm2};

type
  Tform2 = class(TForm)
    Button1: TButton;
    Button2: TButton;
    times: TEdit;
    Label1: TLabel;
    Button3: TButton;
    TimesDone: TEdit;
    RunTimes: TLabel;
    Debug: TEdit;
    Label2: TLabel;
    procedure Button1Click(Sender: TObject);
    procedure Button2Click(Sender: TObject);
    procedure Button3Click(Sender: TObject);
  private
    { Private declarations }
  public
    { Public declarations }
  end;

var
  form2: Tform2;
procedure DoToneToFile(Action,PlaySampleRate,PlayFreq, PlayTime, PlaySides, DelayTime,
              RecordSampleRate, RecordTime:longint; fn:pchar); stdcall;
                external 'TONE4SIN.DLL' index 1;
function DoToneTobuff(Action,PlaySampleRate,PlayFreq, PlayTime, PlaySides, DelayTime,
              RecordSampleRate, RecordTime:longint; buffer:pointer;
                BufferSize:longint):longint; stdcall;
                external 'TONE4SIN.DLL' index 2;

implementation

{$R *.DFM}

procedure Tform2.Button1Click(Sender: TObject);
```

```
begin
 Button1.enabled := false;
 DoToneTofile(3,44000,500,3000,3,000,44000,5000,'test1.wav');
 Button1.enabled := true;
end;

procedure Tform2.Button2Click(Sender: TObject);
var
 BL,BR,BL1,BR1:pchar;
 f,f2:file;
 s:array[1..44] of char;
 sz,i:longint;

type
 pword = ^Word;
begin
 GetMem(BL,200000);
 Button2.enabled := false;
{ StartRecord(44100,1000);}
 sz := DoToneTobuff(3,44100,500,800,3,0,44100,1000,BL,200000);
{ StopRecord;}
{ sz := DoToneTobuff(3,44000,500,10,3,1,44000,20,BL,200000);}
{ sz := DoToneTobuff(3,44000,500,500,3,0,44000,1000,BL, 200000);}
 Button2.enabled := true;
 system.assign(f2,'test1.wav');
 reset(f2,1);
 blockread(f2,s,sizeof(s));
 system.close(f2);
 system.assign(f,'test2.wav');
 system.rewrite(f,1);
{ fillchar(s,sizeof(s),0);}
 blockwrite(f,s,sizeof(s));
 BL1 := BL;
 BR1 := BR;
 for i := 1 to sz div 2 do begin
   blockwrite(f,pword(BL1)^,2);
{   blockwrite(f,pword(BR1)^,2);}
   inc(bl1,2);
{  inc(br1,2);}
 end;
 system.close(f);
 freemem(BL,200000);
end;

procedure Tform2.Button3Click(Sender: TObject);
var
 BL,BR,BL1,BR1:pchar;
 f,f2:file;
 s:array[1..44] of char;
 t,c,sz,i:longint;

type
```

```
 pword = ^Word;
begin
 GetMem(BL,200000);
 Button3.enabled := false;
{function DoToneTobuff(Action1,PlaySampleRate,PlayFreq, PlayTime, PlaySides,
DelayTime,
          RecordSampleRate, RecordTime:longint; buffer:pointer;
BufferSize:longint):longint; stdcall;}

 t := StrToInt(Times.text);
{ StartRecord(44100,100);}
 for i := 1 to t do begin
  TimesDone.text := 'A '+IntToStr(i);
  sz := DoToneTobuff(3,44100,500,100,3,0,44100,100,BL,200000);
  TimesDone.text := 'B '+IntToStr(i);
  TimesDone.Update;
 end;
{ StopRecord;}
 Button3.enabled := true;
 freemem(BL,200000);
end;

end.
```

TestDll.dof

```
[Compiler]
A=0
B=0
C=0
D=1
E=0
F=0
G=1
H=1
I=1
J=1
K=0
L=1
M=0
N=1
O=0
P=1
Q=1
R=1
S=0
T=0
U=0
```

```
V=0
W=0
X=1
Y=0
Z=1
ShowHints=0
ShowWarnings=0
UnitAliases=WinTypes=Windows;WinProcs=Windows;DbiTypes=BDE;DbiProcs=BDE;DbiErrs=BDE;

[Linker]
MapFile=0
OutputObjs=0
ConsoleApp=1
DebugInfo=0
RemoteSymbols=0
MinStackSize=16384
MaxStackSize=1048576
ImageBase=4194304
ExeDescription=

[Directories]
OutputDir=
UnitOutputDir=
PackageDLLOutputDir=
PackageDCPOutputDir=
SearchPath=
Packages=VCL40;VCLX40;VCLDB40;VCLDBX40;VCLSMP40;QRPT40;TEEUI40;TEEDB40;TEE40;DSS40;ibevnt40;VCLMID40;NMFAST40;INETDB40;INET40
Conditionals=
DebugSourceDirs=
UsePackages=0

[Parameters]
RunParams=
HostApplication=

[Version Info]
IncludeVerInfo=0
AutoIncBuild=0
MajorVer=1
MinorVer=0
Release=0
Build=0
Debug=0
PreRelease=0
Special=0
Private=0
DLL=0
Locale=1037
CodePage=1255
```

Appendix C

Assembly Code for Microcontroller

```
;*************** Code sending program ******************

; The format is as follows:
; 1) '1' is frequency transmitting, 'CycNum' times.
; 2) '0' is a quiet period, 'CycNum' times.
; 3) the data is arranged in ascii format (8 bits), in a "retlw 'Value'" format ("Codes" routine).
; 4) each ascii value is preceded by a '1' and is ended by '0' (Sync).
; 5) start of transmission is: 'UW'.
; visa4- 50, 44 cycles per bit.  20Khz, 22.727Khz


        LIST   P=12C509
        list   R=DEC
        INCLUDE      <reg509.inc>          ;register data.

;*****************          Global Declarations     ***************************

CycNum1           EQU   D'25'*1            ;frequency transmitting cycles per bit.
CycNum0           EQU   D'23'*1

Tx          EQU   GP1

Acc         EQU   7
Acc1        EQU   8
CodeI       EQU   0x10
BitCount    EQU   0x11
CycCount    EQU   0x12

;---------------------------------------------

nops:       macro
            nop
            nop
            nop
            nop
            endm

;---------------------------------------------

Reset:
            CLRF  GPIO
            MOVLW       B'00001100'
            TRIS  GPIO
            CLRF  GPIO
```

```
                    movlw B'11011111'
                    option

                    goto    Start

;--------------------------
;according to the index CodeI (>=0) the routine outputs a value in the "dt" table.
;data is transmitted from right to left in the "dt" string.
;length is 7 cycles.

                    org     0x10
Codes:
                    movlw 0x12              ;base address.
                    addwf CodeI,W
                    movwf PCL
                    ;dt     "9999221130016235WU"
                    ;dt     "901234abcde$$%%^^."
                    dt      "4321 .dtL esnesmoC" ;="Comsense Ltd. 1234"


;--------------------------
;each internal loop is 50 cycles long (20.000KHz), on exit there are 16 spare cycles.

Send1:
                    movlw CycNum1
                    movwf CycCount
Send1_L:
                    bsf     GPIO,Tx
                    nop
                    movlw 6
                    call    WaitW           ;22 cycles.
                    bcf     GPIO,Tx
                    decfsz  CycCount,F
                    goto    Send1_L1
                    retlw   0
Send1_L1:
                    nop
                    nop
                    movlw 4
                    call    WaitW           ;16 cycles.
                    goto    Send1_L

;--------------------------
;each internal loop is 44 cycles long (22.727KHz), on exit there are 13 spare cycles.

Send0:
                    movlw CycNum0
                    movwf CycCount
Send0_L:
                    bsf     GPIO,Tx
                    nop
```

```
                movlw 5
                call    WaitW           ;19 cycles.
                bcf     GPIO,Tx
                decfsz  CycCount,F
                goto    Send0_L1
                retlw   0
Send0_L1:
                nop
                nop
                movlw 3
                call    WaitW           ;13 cycles.
                goto    Send0_L

;----------------------
; delay routine: Cycles = 4 + 3*W (1=>7, 2=>10, 3=>13, 4=>16, 5=>19, 6=>22)

WaitW:
                movwf Acc1
WaitWcyc_L:
                decfsz  Acc1,F
                goto    WaitWcyc_L
                retlw   0

;----------------------

Start:
;               call    Send1
;               nop
;               nop
;               movlw 3
;               call    WaitW           ;13 cycles.
;               call    Send0
;               movlw 3
;               call    WaitW
;               goto    Start


                movlw D'18'
                movwf Codel
Send_Digit:
                call    Send1           ;start bit is always '1'.
                nop
                nop
                call    Codes           ;return in "w" the next digit. 7 cycles.
                movwf Acc
                movlw 8
                movwf BitCount
Send_Bit:
                rlf     Acc,F           ;send from MSB to LSB.
                btfss   STATUS,C
                goto    Send_Bit0
                nop
```

```
                call    Send1
                nops
                nop
                nop
                nop
                goto    Send_Bit_L
Send_Bit0:
                call    Send0
                nops
                nop
                nop
Send_Bit_L:
                decfsz  BitCount,F
                goto    Send_Bit

                nops
                nop
                call    Send0           ;stop bit is always '0'.
                nop
                nop
                movlw   2
                call    WaitW           ;10 cycles.
                decfsz  CodeI,F
                goto    Send_Digit



                movlw 1 ;5
                movwf Acc
debug2:
                movlw   D'128'
                movwf   CodeI
debug1:
                movlw   D'255'
                call    WaitW
                decfsz  CodeI,F
                goto    debug1
                decfsz  Acc,F
                goto    debug2

                goto    Start

;-----------------------------

                nops
                nop
                nop

                END
```

```
; Define file for PIC12C5XX

ScratchPadRam  EQU    0x07

; FSRs
INDF           EQU        0
TMR0           EQU        1
PCL                   EQU        2
STATUS                EQU        3
FSR                   EQU        4
OSCAL                 EQU        5
GPIO           EQU        6

; Status Bits
C                     EQU        0
DC                    EQU        1
Z                     EQU        2
PD                    EQU        3
TO                    EQU        4
PA0                   EQU        5
GPWF           EQU        7

; I/O
GP0                   EQU        0
GP1                   EQU        1
GP2                   EQU        2
GP3                   EQU        3
GP4                   EQU        4
GP5                   EQU        5


F                     EQU        1
W                     EQU        0
```

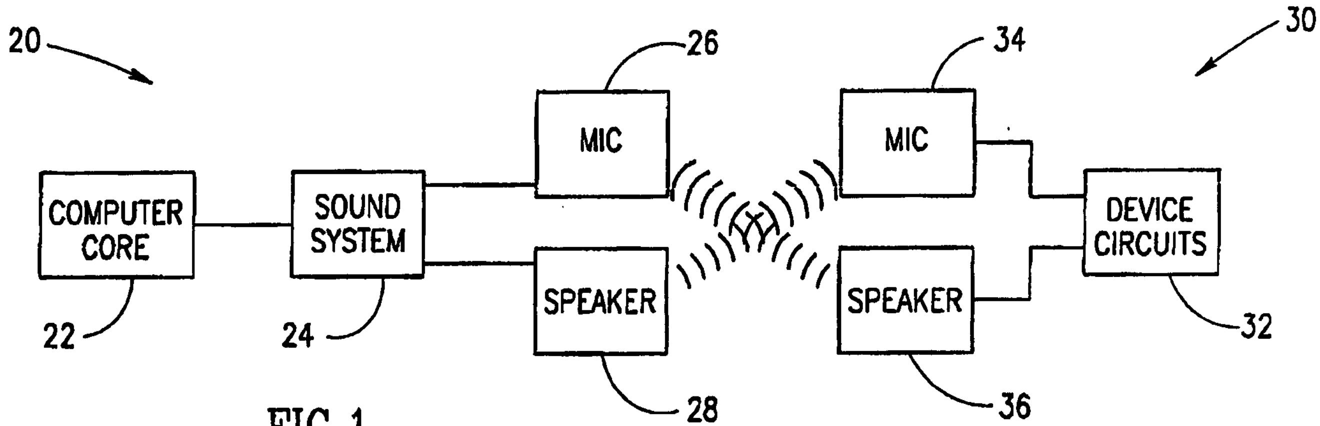

20
COMPUTER CORE
22
SOUND SYSTEM
24
MIC
26
SPEAKER
28
MIC
34
SPEAKER
36
DEVICE CIRCUITS
32
30

FIG.1

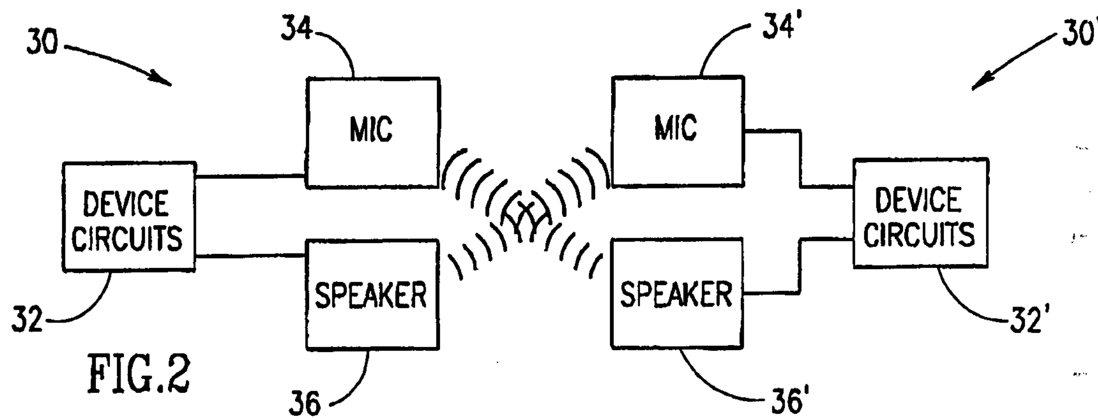

30
DEVICE CIRCUITS
32
MIC
34
SPEAKER
36
MIC
34'
SPEAKER
36'
DEVICE CIRCUITS
32'
30'

FIG.2

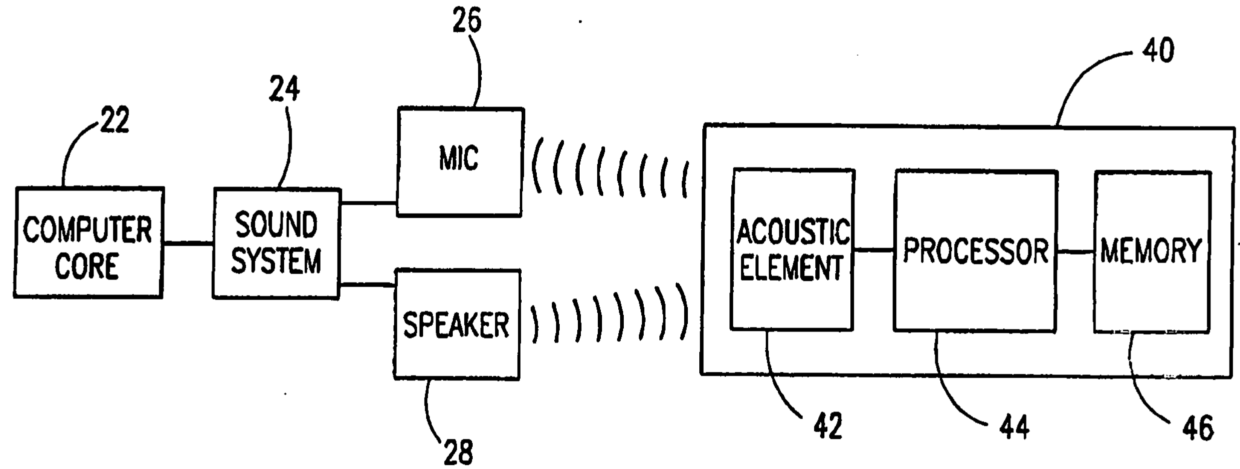

COMPUTER CORE
22
SOUND SYSTEM
24
MIC
26
SPEAKER
28
40
ACOUSTIC ELEMENT
42
PROCESSOR
44
MEMORY
46

FIG.3A

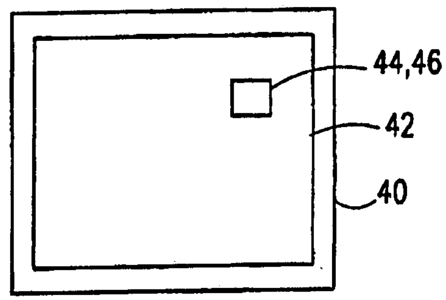


FIG.3B

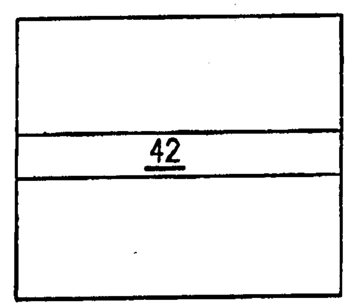


FIG.3C

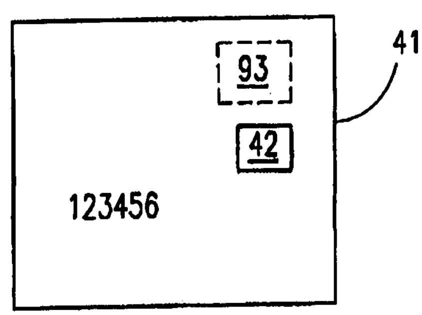


FIG.3D

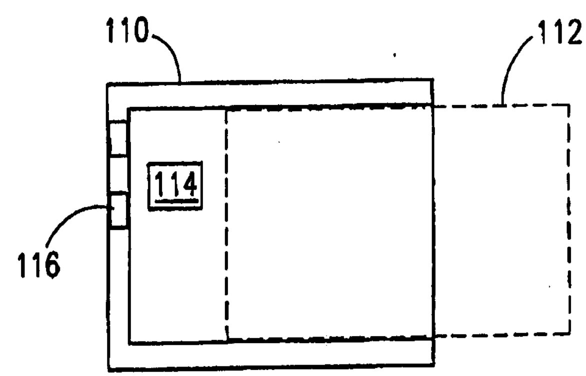
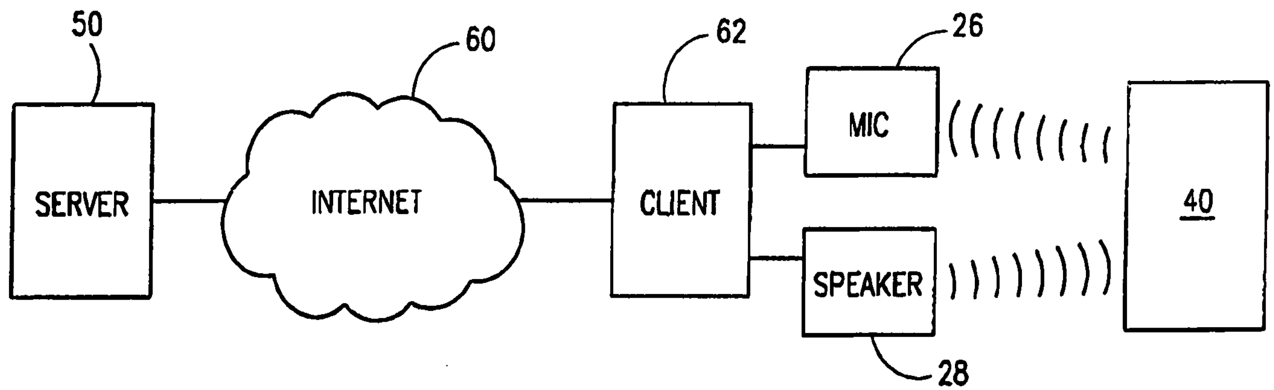
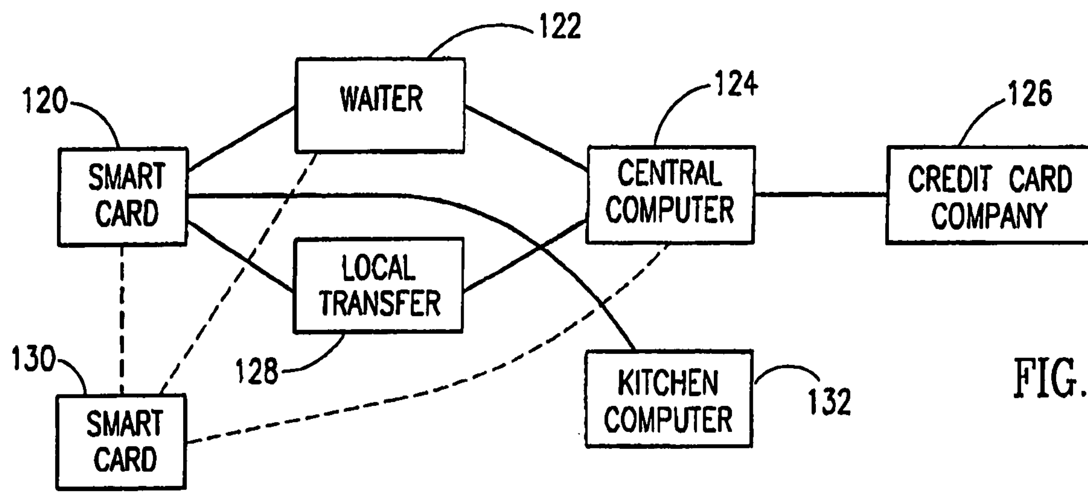


FIG.3E



50
SERVER
60
INTERNET
62
CLIENT
26
MIC
SPEAKER
28
40

FIG.4A



120
SMART CARD
122
WAITER
124
CENTRAL COMPUTER
126
CREDIT CARD COMPANY
LOCAL TRANSFER
128
130
SMART CARD
KITCHEN COMPUTER
132

FIG.4B

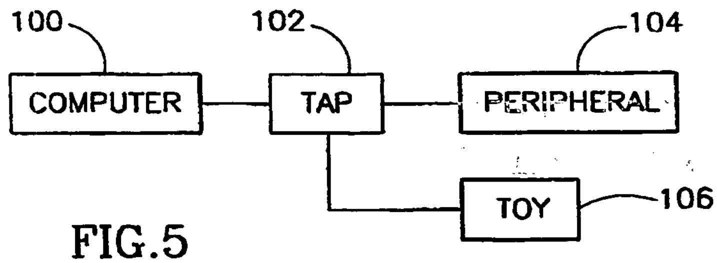


FIG.5

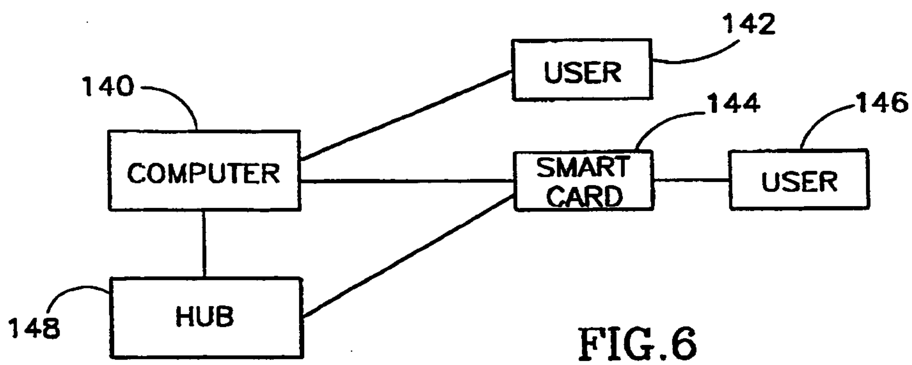


FIG.6

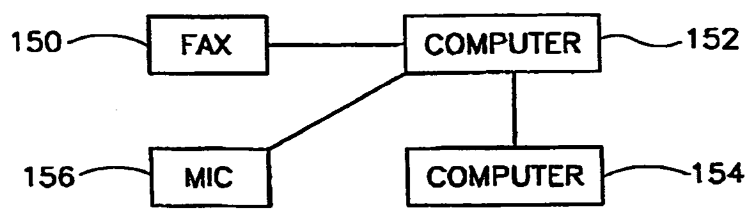
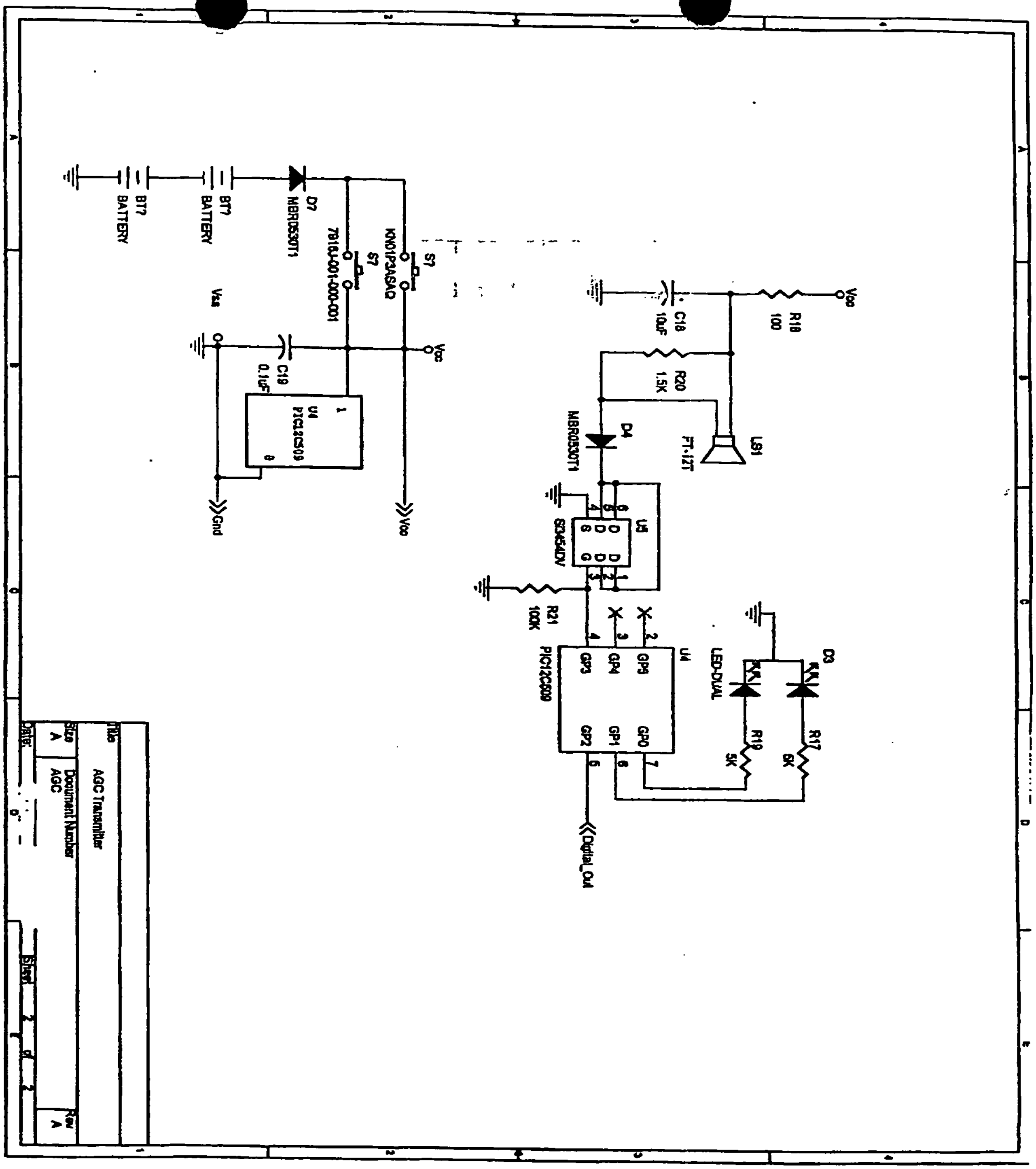


FIG.7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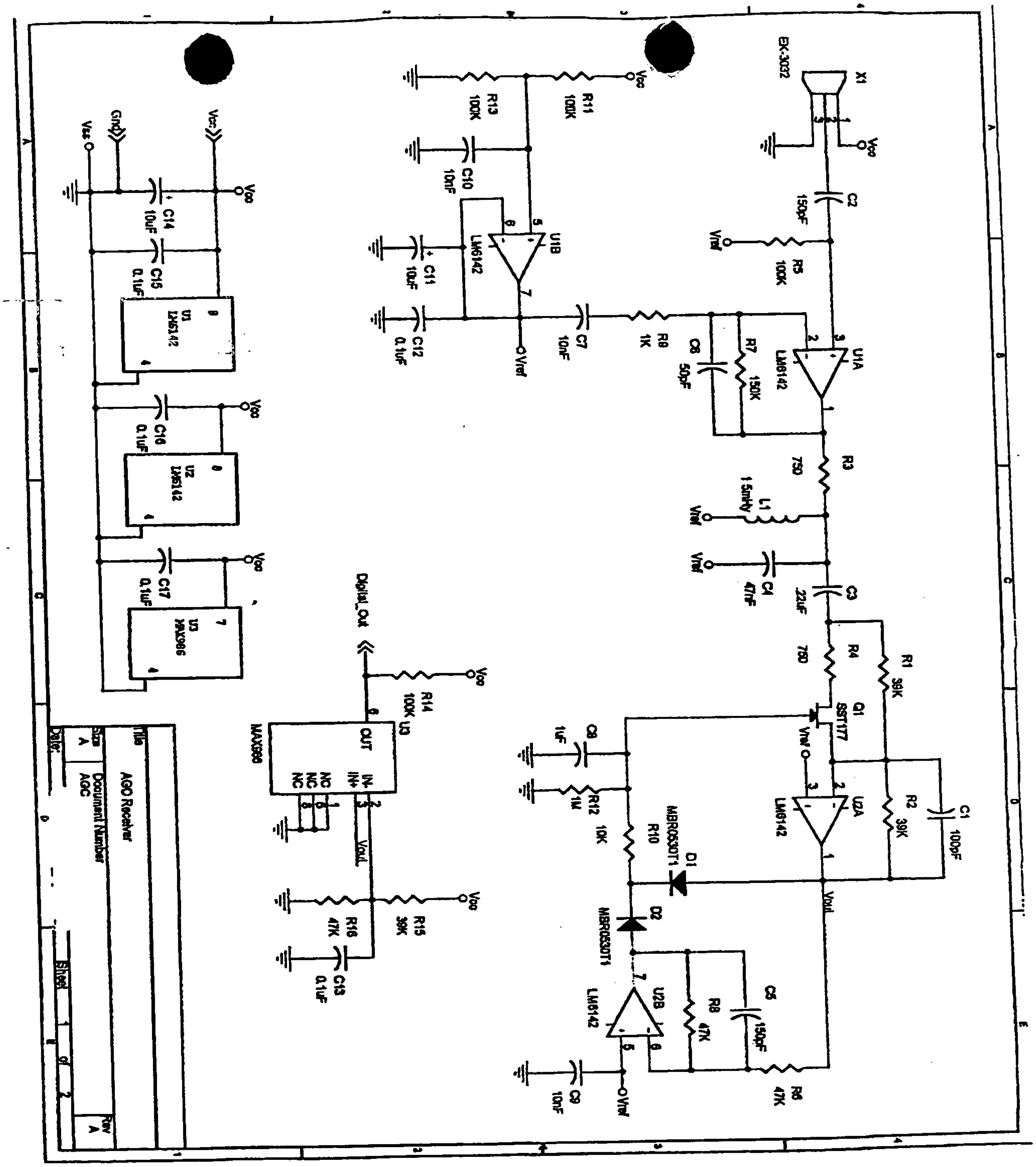
Vcc
Gnd
Vss
C19
0.1uF
C18
10uF
R18
100
R20
1.5K
LS1
MBR0530T1
U5
R21
100K
U4
PIC12C509
GP5
GP4
GP3
GP0
GP1
GP2
D3
LED-DUAL
R17
5K
R19
5K
Digital_Out
Title
AGC Transmitter
Size
A
Document Number
AGC
Rev
A
Sheet

Fig 8A



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Document Number
AGC
Title
Size
A
Date:
Sheet 1 of 2
Rev
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EK-3032
X1
Vcc
Vref
Vss
Gnd
Vout
Digital_Out
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U1B LM6142
U2A LM6142
U2B LM6142
U3 MAX986
U1 LM6142
U2 LM6142
Q1 SST177
D1 MBR0530T1
D2 MBR0530T1
L1 15mHy
R1 39K
R2 39K
R3 750
R4 750
R5 100K
R6 47K
R7 150K
R8 47K
R9 1K
R10 10K
R11 100K
R12 1M
R13 100K
R14 100K
R15 39K
R16 47K
C1 100pF
C2 150pF
C3 .22uF
C4 47nF
C5 150pF
C6 1uF
C7 10nF
C8 50pF
C9 10nF
C10 10nF
C11 10uF
C12 0.1uF
C13 0.1uF
C14 10uF
C15 0.1uF
C16 0.1uF
C17 0.1uF
OUT
IN-
IN+
NC

Fig 8B